

Semivolatile Organic (GC-MS) and Inorganic Analyses of Groundwater Samples During the Hydrous Pyrolysis/Oxidation (HPO) Field Test in Visalia, California, 1997

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Robin L. Newmark, and Kevin G. Knauss**

February 5, 1998

The logo of the Lawrence Livermore National Laboratory, featuring a stylized 'U' and 'L' symbol to the left of the text 'Lawrence Livermore National Laboratory' which is arranged in four lines and rotated diagonally.

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**Lawrence Livermore National Laboratory
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Acronyms and Abbreviations

DAFT	dissolved-air flotation tank
DIC	dissolved inorganic carbon
DNAPL	dense, nonaqueous-phase liquid
DUS	dynamic underground stripping
EPA	U.S. Environmental Protection Agency
EW	extraction well
FID	flame ionization detector
GC-MS	gas chromatography–mass spectrometry
HPO	hydrous pyrolysis/oxidation
i.d.	internal diameter
LLNL	Lawrence Livermore National Laboratory
LNAPL	light, nonaqueous-phase liquid
MW	monitoring well
PAH	polycyclic aromatic hydrocarbons
RIC	reconstructed ion chromatogram
SPE	solid-phase extraction
TIC	total inorganic carbon
UCM	unresolved complex mixture

Abstract

Hydrous pyrolysis/oxidation (HPO) is a novel, in situ, thermal-remediation technology that uses hot, oxygenated groundwater to completely oxidize a wide range of organic pollutants. A field demonstration of HPO was performed during the summer of 1997 at the Southern California Edison Pole Yard in Visalia, California, a site contaminated with creosote. The goal of the field experiment was to confirm the success of HPO under field remediation conditions. The groundwater was heated by steam injections, and oxygen was added by co-injection of compressed air. The progress of the HPO remediation process was evaluated by monitoring groundwater from multiple wells for dissolved oxygen, dissolved inorganic carbon, and dissolved organic contaminant levels.

Analyses of groundwater chemistry allowed us to measure the concentrations of creosote components and to identify oxygenated intermediates produced by the HPO treatment. Dissolved organic carbon levels increased in response to steam injections because of the enhanced dissolution and mobilization of the creosote into the heated groundwater. Elevated concentrations of phenols and benzoic acid were measured in wells affected by the steam injections. Concentrations of other oxygenated compounds (i.e., fluorenone, anthrone, and 9,10-anthracenedione) increased in response to the steam injections. The production of these partially oxidized compounds is consistent with the aqueous-phase HPO reactions of creosote.

Additional changes in the groundwater in response to steam injection were also consistent with the groundwater HPO chemistry. A drop in dissolved oxygen was observed in the aquifer targeted for the steam injections, and isotope shifts in the dissolved inorganic pool reflected the input of oxidized carbon derived from the creosote carbon.

Introduction

The 4.3-acre Southern California Edison Pole Yard in Visalia, California, operated for 80 years as a wood preservation treatment facility. Because of this operation, this site is contaminated with a dense, nonaqueous-phase liquid (DNAPL) mixture composed of pole-treating creosote and an oil-based carrier fluid containing pentachlorophenol. After the site was placed on the EPA Superfund list in 1977, pump and treat technology was deployed to reduce and contain the contaminant plume. Over nearly 20 years, an estimated 10,000 lb of contaminant were removed from the soil and groundwater.

In the summer of 1997 Southern California Edison began the application of two thermally enhanced remediation technologies to accelerate the clean-up. The first method, dynamic underground stripping (DUS), involves steam injection coupled with vacuum extraction to enhance the mobilization and removal of free product (Newmark and Aines, 1995). The second method, hydrous pyrolysis/oxidation (HPO), is a novel, in situ, thermal-remediation technology that uses hot, oxygenated groundwater to destroy organic contaminants by completely oxidizing the organic pollutants to carbon dioxide. The supplemental oxygen is delivered in the form of injected air. HPO is needed to destroy the residual DNAPL components not readily removed by the DUS process.

Initial laboratory-based feasibility experiments have been conducted to investigate the HPO of actual DNAPL material with excess dissolved O_2 under conditions similar to those achievable during thermal-remediation (Knauss et al., 1998a; Leif et al., 1998). These experiments demonstrated that dissolved O_2 readily reacts with the compounds present in the DNAPL creosote mixture to form products ranging from partially oxidized intermediates, such as phenols and benzoic acid (Figure 1), to the fully oxidized product CO_2 (Figure 2).

Field implementation of HPO remediation at the Southern California Edison Pole Yard site was initiated in May 1997 using 11 steam injection wells encircling the creosote DNAPL pool (Figure 3). The lithology is shown in Figure 4 and consists of three aquifers. The shallow aquifer (approx. 35–70 ft below ground surface) and the intermediate aquifer (approx. 75–102 ft below ground surface) are both contaminated with DNAPL. The intermediate aquifer was targeted for the HPO field demonstration.

The focus of the Lawrence Livermore National Laboratory (LLNL) field demonstration effort was steam-injection Well S-4. This well was used for the HPO demonstration, and groundwater chemistry (pH, total inorganic carbon, dissolved oxygen, anions, cations, and organic semivolatile compounds) was monitored at Wells MW-36 (approximately 80 ft away) and S-13 (approximately 95 ft away). Several additional wells were also monitored periodically for groundwater chemistry. This report concentrates on the results of the semivolatile organic compounds extracted from the groundwater by solid-phase extraction (SPE) and identified and quantitated by gas chromatography–mass spectrometry (GC-MS).

Analytical Methods

Sampling and Sample Preservation

Water samples for inorganic and organic analyses were taken at several monitoring and extraction wells on the Southern California Edison Pole Yard complex. Each sampling event involved collecting water samples for both inorganic and organic analyses. Water samples were collected in the following sample containers: water samples for pH were collected in certified 40-mL VOA vials (I-Chem) and filled to eliminate any headspace; samples for total inorganic carbon (TIC) and anions were collected in 4-mL screw-cap vials and filled to eliminate any headspace; water for cations were collected in 500-mL Nalgene bottles (high density polyethylene with polypropylene screw closure); water samples for semivolatile organic analyses by extraction and concentration using SPE cartridges were taken in certified clean 1-liter borosilicate amber bottles with Teflon™-lined caps; water samples for field liquid-liquid extraction were collected in 500-mL volumetric flasks. Samples for cation analysis were acidified to pH <2 with concentrated nitric acid, and water samples for both SPE extraction and field liquid-liquid extraction were acidified to pH <2 with hydrochloric acid. An attempt was made to keep samples refrigerated until analysis.

Extraction

Liquid-Liquid Extraction. Water samples taken in the 500-mL volumetric flasks were allowed to come to ambient temperature and volume adjusted to 500 mL. To this flask was added 2.0 mL of hexane containing an internal standard (2-bromonaphthalene at 200 µg/mL), and the flask was inverted several times and shaken for a duration of 1 minute to standardize the field extraction method.

Solid-Phase Extraction (SPE). Priority pollutants were extracted and concentrated by SPE prior to analysis by GC and GC-MS. Typically a water sample ranging in volume from 1 to 4 liters was flowed by positive pressure through an SPE cartridge packed with 200 mg of ENV+ (International Sorbent Technology), a highly crosslinked styrene-divinylbenzene resin suitable for extraction of nonpolar and polar compounds from water. After sample extraction, the SPE tubes were dried and eluted with 4.5 mL of a dichloromethane/isopropanol mixture (1:1). Sample bottles were also eluted with this solvent mix (1:1) to extract organic compounds adsorbed to the glass. All extracts were spiked with a six-component internal-standard mix.

Field Analyses

Measurement of pH. The water samples taken for pH were allowed to come to ambient temperature before analysis. The measurement of pH was performed using a Sentron 2001 pH meter employing a hydrogen-ion-sensitive ion-selective field effect transistor (ISFET) with automatic temperature compensation. Calibration of the meter was done at the beginning of each day using pH standard solutions (pH 4 and pH 7) and checked before each measurement using the pH 7 buffer solution.

Gas Chromatography. Field measurements of the total organic hexane extract were performed on an SRI 9300 gas chromatograph, equipped with a flame ionization detector (FID) in tandem with a dry electrolytic conductivity detector (ELCD). Compounds were injected on-column and separated on an MXT-5 Restek 15-m mega-

bore (0.53 mm i.d.) capillary column. The temperature was programmed from 40°C (initial hold time 1.0 min) to 200°C at 10°C/min. Helium was used as the carrier gas. Data were acquired and integrated using SRI PeakSimple software. Quantitation for total organic carbon for components amenable to gas chromatographic analyses was calculated relative to the internal standard using a response factor of 1.0. Results of these analyses are presented elsewhere (Chiarappa et al., 1998).

Laboratory Analyses

Gas Chromatography. Laboratory analyses of the organic extracts were conducted on a Hewlett-Packard 5890 Series II gas chromatograph equipped with an FID and an HP 7673 automatic sampler. Compounds were injected in splitless mode on a 30-m (0.53 mm i.d.) fused silica capillary column coated with methylpolysiloxane (DB-5, J & W Scientific; film thickness 0.5 µm). Instrument temperature was increased from 60°C (initial hold time 2 min) to 270°C at 12°C/min. Helium was used as the carrier gas. Data were acquired and integrated using the HP Series II Chemstation software. Results of these analyses are presented elsewhere (Chiarappa et al., 1998).

Gas chromatography-mass spectrometry. Gas chromatography-mass spectrometry (GC-MS) analyses of the SPE extracts were performed on a Hewlett Packard 6890 gas chromatograph equipped with a 30 m × 0.25 mm i.d. HP-5ms (5% phenyl methylsiloxane) capillary column (0.25 µm film thickness) coupled to a Hewlett Packard 6890 Series Mass Selective Detector, operated in electron impact mode (70 eV) over the mass range 35–450 dalton with a cycle time of 1.1 s. The GC oven temperature was programmed at isothermal for 2 min at 50°C, increasing by 8°C/min to 300°C, and isothermal for 6.75 min, with the injector at 250°C and helium as the carrier gas. The MS data were processed using Hewlett Packard Chemstation software. Internal standard method, using relative response factors, was used to quantitate the target compounds. Target compounds quantitated for this study are listed in Appendix A.

Total Inorganic Carbon. TIC analyses were obtained using an OI Model 524 analyzer. A weighed sample was injected into a purge vessel containing a 25% phosphoric acid solution, which was continuously purged with nitrogen gas. The dissolved inorganic carbon converted to CO₂ and was swept into a nondispersive infrared detector, where measurement of total inorganic carbon was made.

Anions. Anion concentrations were determined using a Hewlett Packard 1090M HPLC coupled to a Waters 431 conductivity detector. Data were processed using an on-line Hewlett Packard personal computer with Chemstation software.

Cations. Cation analysis was done by the Analytical Chemistry Section at LLNL using inductively-coupled plasma atomic emission spectrometry (ICP-AES).

Quality Assurance. A series of quality control and monitoring steps were followed during the field test. The major steps included field and laboratory blank tests, solvent tests to monitor for possible contaminants, and recovery experiments for a large set of representative polar and nonpolar standard compounds.

Results

The field experiment at the Visalia Pole Yard involved injections of steam and steam with compressed air into the intermediate aquifer from injection Well S-4. The effects of the steaming operation were monitored by sampling the intermediate aquifer using Wells MW-36 and S-13, located approximately 90 ft away. Wells MW-36 and S-13 were the two sampling wells regularly sampled to assess the progress of the steam injection experiments. Therefore, the water chemistry data for organic analyses were primarily from these two wells.

In addition to these two wells, water samples were periodically collected from S-12, S-14, S-15, MW-41, MW-44, EW-1, EW-2, EW-3, and EW-5. Two water samples of condensed steam from the steam injection Well S-4 were also collected and analyzed by GC-MS. Some miscellaneous water samples and free product samples were collected from venting wellheads or the treatment facility. One sample of creosote free product collected in 1996 was analyzed for comparison purposes. These samples were diluted in solvent and analyzed by GC-MS. The list of semivolatile organic target compounds quantitated during this study was derived from EPA Method 8270C and consisted primarily of polycyclic aromatic hydrocarbons (PAH) and phenols. This target compound list was expanded to include all three tetrachlorophenol isomers, three additional oxygenated compounds (fluorenone, anthrone, and 9,10-anthracenedione), and two nitrogen-containing PAH compounds (carbazole and 7,8-benzoquinoline). The analytical results of the GC-MS analyses are listed in Appendix B. Summarized at the bottom of each table in Appendix B are the following:

- Total Oxygenates ($\mu\text{g/L}$): Sum of non-chlorinated phenols in EPA 8270C list plus benzoic acid, fluorenone, anthrone, and 9,10-anthracenedione
- Total PAH ($\mu\text{g/L}$): Sum of PAH in EPA 8270C list (including dibenzofuran) plus nitrogen-containing PAH (carbazole and 7,8-benzoquinoline)
- Total Cl-Phenols ($\mu\text{g/L}$): Sum of three tetrachlorophenol isomers and pentachlorophenol
- Total GC-MS ($\mu\text{g/L}$): Sum of all compounds in entire expanded EPA 8270C target compound list

Although Total GC-MS ($\mu\text{g/L}$) is a sum of all target compounds, it does not represent the total amount of organic contaminants extracted from the water samples amenable by gas chromatography. The Total GC-MS ($\mu\text{g/L}$) value represents a sum of those compounds listed in the EPA Method 8270C plus those compounds included in the expanded analyte list discussed above. This point can be illustrated by examining three examples of the raw GC-MS data and quantitation results. Figure 5 and Figure 6 are representative reconstructed ion chromatograms (RIC) for the GC-MS runs of the organic extracts from Wells S-13 (June 19 22:25) and S-14 (June 17 11:15), respectively. Figure 7 is the RIC for a sample of free product collected from the dissolved-air flotation tank (DAFT) on July 16; y is abundance and x is time. These three chromatograms represent abundances of the target analytes (labeled) relative to the six internal standards (labeled IS-1 through IS-6). From these three figures it is apparent that many compounds were not quantitated and, for some samples, a significant portion of the extracted organic compounds has remained chromatographically unresolved and unquantitated in the unresolved complex mixture (UCM). For example, the total amount of organic compounds quantitated by GC-MS using this target compound list for the

DAFT (July 16) free product sample accounts for 16% of the sample mass. The remaining, unquantitated portion consists of alkylated PAH (i.e., di- and trimethylnaphthyl- enes) and compounds which make up the UCM. Therefore, the Total GC-MS value is a sum of the compounds in the target compound list and represents a portion of the total organics amenable by GC and quantitated by a flame ionization detector (FID). A complete discussion of the results of GC-FID is presented by Chiarappa et al. (1998).

For simplicity in the results and discussion sections, the PAH compounds have been further subdivided by molecular weight into three groups; low molecular weight PAH (two-ring PAH, i.e., naphthalene and 2-methylnaphthalene), intermediate molecular weight PAH (three-ring PAH, i.e., acenaphthene, fluorene, and phenanthrene), and high molecular weight PAH (four- and five-ring PAH, i.e., fluoranthene, pyrene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene). This classification aids in the general description of the distribution of the organic compounds present in the water samples.

The analyses quantitated by GC-MS were compounds whose positive identifications were confirmed by GC retention time match and mass spectral match with a standard mixture made up of pure compounds at known concentrations (Hale and Aneiro, 1997). The oxygenated compounds in the analyte list, although possibly present in the creosote-contaminated soil as minor compounds, could also be formed during HPO and may be representative of partially oxidized PAH compounds. The complete GC-MS results are presented in Appendix B, Tables 1–9. A brief description of the results from each well follows.

Well MW-36

Table 1 lists the results of the groundwater analyses from Well MW-36. This well was sampled for groundwater organic pollutants on May 7 to obtain a baseline sample representative of groundwater before the injection of steam and was found to be clean of organic contaminants.

The first injection of steam into S-4 began on May 21 and lasted until May 23. Six samples were collected during this period and analyzed for TIC and semivolatile organics before the pump temporarily failed on May 22. This set of samples represents groundwater that has been displaced by the growing steam zone. Total semivolatile organic analyses for these six samples were low, with an average total semivolatile organic level of approximately 12 ppb, and exhibited no trends in organic contaminant levels as a function of time.

Ten samples were taken for semivolatile organic analyses from May 28 to June 4. During this time organic-compound levels were increased substantially over the earlier samples. The water sample of May 28 17:10 had PAH components ranging from naphthalene (molecular weight 128) to pyrene (molecular weight 202), with the most abundant being phenanthrene (molecular weight 178) at a concentration of 350 ppb. Some oxygenated compounds were present, and a total oxygenate concentration of 44 ppb was quantitated. The most abundant oxygenate was fluorenone at a concentration of 27 ppb. Eight water samples taken from June 2 to June 4 exhibited large variabilities in concentrations of groundwater organics. Difficulties were encountered during this period with the pump installed in the well; some of the large variations in organic concentrations may have been due to these operational difficulties and not to actual groundwater fluctuations. But it was obvious that the levels of PAH and oxygenates in these water samples were still elevated and similar in composition to the May 28 17:10 sample discussed above. The average total oxygenate concentration was

41 ppb, with benzoic acid and fluorenone being the most abundant oxygenated compounds present. The average total PAH concentration was 650 ppb for these three samples, with phenanthrene being the most abundant single PAH component.

A total of 13 water samples were extracted and analyzed by GC-MS from June 17 to June 30. This sample set covers the time when steam and compressed air were injected into S-4 (June 17–20). The earliest sample taken on June 17 had total organics at approximately 200 ppb. The levels of organics in MW-36 did not change much until June 20, when the total organic level increased to > 1000 ppb, and it peaked at 2300 ppb on June 26, approximately one week after the steam/compressed-air injection. The level of total oxygenates also peaked at 55 ppb approximately one week after the injection. Fluorenone, 9,10-anthracenedione, and benzoic acid were the most abundant oxygenated compounds.

The four histograms in Figure 8 show how the relative abundances of the target analytes changed over time. As stated above, the pre-steam baseline sample was clean of semivolatile compounds. From May 28 to the end of sampling on June 30, the most abundant compound was phenanthrene, but over this time there was a relative increase in the higher molecular weight PAH compounds (i.e., fluoranthene and pyrene).

Well S-13

Table 2 lists the results of the groundwater analyses from Well S-13. Sampling at this well began on May 23 and continued throughout the field experiment. The last regular sample to monitor the S-4 steam injection was taken on July 16. Two additional spot-check samples were acquired on October 23 and December 16.

The earliest sample acquired from S-13 (May 23 08:30) was taken as the steam front from the initial steaming event reached the vicinity of the S-13/MW-36 sampling location. Total organics for this sample was 4307 ppb. A sample taken later on the same day (S-13 May 23 13:50), after the collapse of the steam zone, had the same distribution of organics but at a lower total concentration (682 ppb).

The next sample was taken on May 28 and was elevated in both total oxygenates and total PAH (primarily phenanthrene). The levels of contaminants steadily decreased during the following two weeks and stabilized by June 17 at a total organic level of approximately 700 ppb. Steam/compressed-air injection into S-4 began on June 17 and continued to June 20. Contaminant levels were elevated by June 19 22:25. The total oxygenate concentration was 89 ppb, consisting primarily of benzoic acid, fluorenone, and 9,10-anthracenedione, and the total PAH concentration was > 4000 ppb with phenanthrene being the most abundant compound. The contaminant level remained elevated for another week. By June 30 the contaminant level started to decrease, and by July 16 the oxygenate and PAH concentrations were at their lowest levels.

Figure 9 shows histograms of the semivolatile organic data for May 23, June 16, June 30, and December 16. In Figure 9a through Figure 9c the relative distribution of semivolatile compounds remained quite constant. There was a slight shift to higher molecular weight compounds during this period. The most abundant compound during this time was phenanthrene, but the relative abundances of the lower molecular weight compounds decreased while two higher molecular weight compounds (fluoranthene and pyrene) increased in relative concentration. The last sample, taken on December 16 (Figure 9d), had a much different compound distribution. The relative amounts of oxygenates were up (i.e., benzoic acid and fluorenone), but, unlike all the previous water samples from S-13, pentachlorophenol and two tetrachlorophenol isomers were elevated in the water sample.

Well S-12

Table 3 lists the results of the groundwater analyses from Well S-12. This well was sampled six times from May 20 to July 16. These water samples were high in organic contaminants; total organics by GC-MS ranged in concentrations from approximately 1000 ppb to nearly 5000 ppb. The contaminants consisted primarily of the intermediate molecular weight PAH compounds (i.e., phenanthrene). Total oxygenate concentrations steadily decreased from 283 ppb on May 20 to 31 ppb measured on June 17. By July 17 the total oxygenate concentration was again elevated to a value of 215 ppb. Although the total oxygenate concentrations were dominated by the compound fluorenone, there were also significant amounts of total phenols, anthrone, and 9,10-anthracenedione present in the water samples.

Figure 10 presents four histograms showing the distributions of semivolatile compounds from May 20 to July 16 for Well S-12. The first sample taken from this well was unique in that it had relatively high concentrations of heteroaromatic compounds (i.e., carbazole and dibenzofuran) in addition to the relatively high levels of oxygenates (primarily fluorenone). As seen with the distribution of semivolatile compounds over time in Wells MW-36 and S-13, a relative shift to higher molecular weight compounds over time was also observed in the water samples from this well.

Well S-14

Table 4 lists the results of the groundwater analyses from Well S-14. This well was sampled seven times from May 6 to July 16, with one additional sample taken on December 16. The results of May 6 represent a pre-steam cold baseline sample, high in PAH (i.e., naphthalene, acenaphthene and phenanthrene) and low in oxygenates. A general increase in total organics was observed during the period of the field test, with a large spike of total organics on June 30. A steady increase in total oxygenates was observed during the field test. On July 16 the total oxygenates value was 270 ppb, much higher than the value of 12 ppb measured in the baseline sample of May 6. Although there was a steady increase in the level of the oxygenates, the percentage of oxygenates remained relatively low and constant throughout the entire test period.

Figure 11 shows histograms of the semivolatile analyses from May 6, June 17, July 16 and December 16. No real systematic variations in the semivolatile compound distributions were evident over the six-month period when samples from this well were collected. The baseline sample of May 6 consisted primarily of low (i.e., naphthalene and 2-methylnaphthalene) and intermediate (i.e., acenaphthene, fluorene, and phenanthrene) semivolatile organic compounds, with significant amounts of carbazole and dibenzofuran. By June 17, the distribution became dominated by the low molecular weight compounds. When sampled again on July 17, the compound distribution again resembled the baseline sample of May 6. The last sample (December 16) was again dominated by the low molecular weight PAH and resembled the sample of June 17.

Well S-15

Table 5 lists the results of the groundwater analyses from Well S-15. This well was sampled for organics three times during the HPO field test, on May 28, June 30, and July 16, with two additional samples collected on December 16 as spot-check samples. This well exhibited the same trends in contaminant concentrations seen in Well S-14, showing increases in total oxygenates and total PAH over time. The earliest sampling date of May 28 had a total organic level of 4280 ppb. The level of organics increased to

12000 ppb on June 30 and 15300 ppb on July 16. The levels of total oxygenates increased from 150 ppb on May 28 to nearly 400 ppb on July 16. The most abundant compounds present were the low and intermediate molecular weight PAH compounds (i.e., naphthalene and phenanthrene) and pentachlorophenol. Although the level of pentachlorophenol was low (18 ppb) in the May 28 sample, the PCP level increased to 2000 ppb by June 30 and was measured at 3400 ppb on July 16.

Figure 12 presents four histograms sampled from May 28 to December 16, covering approximately the same time period as was shown in Figure 11 for Well S-14. The sample of May 28 consisted of compounds spanning a large molecular weight range, from naphthalene to pyrene. On June 30 the distribution was dominated by naphthalene with lesser amounts of the other PAH. A similar distribution was found on July 17. On December 16 the major compound present was phenanthrene.

Miscellaneous Wells (MW-41, MW-44, EW-1, EW-2, EW-3, EW-5)

Table 6 lists the results of the groundwater analyses from a set of assorted wells. The wells listed in this section were not sampled on a regular basis but rather were collected as spot checks around the site.

MW-41 was sampled three times during the field test. The first sample was taken on May 6 and represented a baseline sample before steaming operations began. The water on this date was clean of semivolatile compounds, and none of the target compounds were detected. Midway through the steaming operations, another sample was taken (June 18) and some target compounds were detected at very low levels. The total semivolatile compound level quantitated by GC-MS was approximately 20 ppb. A final sample was taken on July 16 and was similar to the previous sample taken on June 18. Most of the compounds detected were in the range of 1–7 ppb with the exception of pentachlorophenol, which was at 19 ppb.

One sample from MW-44 was taken on July 17. A few semivolatile organic compounds were detected at very low levels (approximately 1 ppb). EW-1 was sampled on May 8 and June 16. PAH compounds at concentrations < 40 ppb were found in both samples and both had total semivolatile levels of approximately 140 ppb. EW-3 was sampled on May 6 and June 16. The May 6 sample consisted primarily of intermediate molecular weight PAH (i.e., acenaphthene, dibenzofuran, and phenanthrene) at approximately 40 ppb and a total semivolatile organic loading of 180 ppb. The EW-3 sample taken on June 16 had a similar compound distribution except for elevated levels of fluorenone and phenanthrene. This sample had a total semivolatile concentration of 390 ppb. EW-5 was sampled once (July 17) and was relatively clean, having a total semivolatile concentration of 28 ppb. Wells EW-5, MW-41 and MW-44 were the cleanest of all the wells sampled after the steaming operations began.

Injection Well S-4

The steam injection Well S-4 was sampled twice for organic analyses by GC-MS. The results are presented in Appendix B, Table 7. The sample dated May 23 13:30 was collected by condensing steam from the S-4 wellhead into ice, so the concentrations for this sampling event include an unknown dilution factor and should be used only as a qualitative look at which organic compounds vented from this well. The analysis showed the condensed steam was quite clean in hydrocarbons with phenanthrene as the compound in highest concentration.

Well S-4 was sampled on June 20 13:00 by condensing the steam in a copper coil submerged in an ice bath, then collecting the water in a 1L amber sampling bottle. This

analysis revealed that the major compounds present were the intermediate molecular weight PAH compounds of phenanthrene (89 ppb), pyrene (23 ppb), fluoranthene (11 ppb) and anthracene (10 ppb). A small grab sample from Well S-4 was also taken on June 20 11:00 and analyzed for pH (pH = 7) and TIC (75.9 $\mu\text{g C/g H}_2\text{O}$).

Miscellaneous Water and Free Product

Miscellaneous water samples are listed in Table 8, and miscellaneous free product and solid samples are listed in Table 9. The water samples submitted for organic analyses and listed in Table 8 were either condensed vapor samples from Well S-13 or water samples from the treatment facility. As expected for samples of this type, all of these water samples were elevated in organics. Two histograms of condensed vapor from S-13 are presented in Figure 13a and Figure 13b. These samples were unique because they both had extremely elevated organic concentrations but also very limited in the distribution of organic compounds present. For example, the S-13 (June 20) condensed vapor sample consisted primarily of phenanthrene, and the S-13 (June 30) sample consisted almost exclusively of phenanthrene, anthracene, fluoranthene, and pyrene. The distribution of organic compounds found in the water samples from the treatment facility were nearly identical, with the major compound being 2-methylnaphthalene.

Selected histograms of free products, sludge samples, or emulsion samples are presented in Figure 14 and Figure 15. Figure 14a is a histogram of a creosote sample recovered in 1996 from the vicinity of Well S-14. Figure 14b is a sample of the free product collected from the gravity separator on June 19. The distribution of compounds found in this sample is similar to the creosote sample. The bottom sludge sample collected at the same time is depleted in the lower molecular weight components. The sample from the DAFT (June 19) consisted primarily of intermediate and high molecular weight compounds of phenanthrene, fluoranthene, and pyrene. Figure 15 presents free product samples taken from various locations in the treatment facility. They are all similar in composition, consisting primarily of 2-methylnaphthalene, with lesser amounts naphthalene and the intermediate molecular weight PAH.

Figure 16a and Figure 16b present results from solid samples, collected on June 30, of material that had condensed on the S-13 wellhead. The distributions consisted primarily of intermediate and high molecular weight compounds (i.e., phenanthrene, anthracene, fluoranthene, and pyrene). Figure 16c and Figure 16d are organic compounds extracted from carbonate scales collected from Wells S-13 and S-15. Like the S-13 wellhead samples, these samples had very limited distributions of organic compounds consisting primarily of phenanthrene and the higher molecular weight compounds fluoranthene and pyrene.

Discussion

Large variations were found in groundwater contaminant concentrations and compound distributions in water samples from the Southern California Edison Pole Yard. The possible causes of these variations are numerous. Some of the observed differences could have resulted from more than one creosote, dense, nonaqueous-phase liquid (DNAPL) type being present in the intermediate aquifer. The composition of a complex creosote DNAPL pool also can be altered by a variety of physical, chemical, and biochemical processes (Goerlitz et al., 1985). An example of a physical alteration would be the preferential loss of more soluble compounds to the groundwater (Johansen et al., 1997), and an example of a chemical alteration would be the chemical oxidation that occurs at extremely slow rates under ambient conditions but can be greatly accelerated by steam injections (Knauss et al., 1998a; Leif et al., 1998). An example of a biochemical alteration would be the selective utilization of certain types of creosote compounds by microorganisms (Erlich et al., 1982; Mueller et al., 1991).

Prior to any clean-up attempts, the alteration processes acting on the creosote DNAPL and contaminated groundwater were not occurring fast enough to allow natural attenuation to contain the contaminated groundwater plume or remediate the source DNAPL on the site. The application of pump and treat technology contained the plume but did not remove the large source of DNAPL at an acceptable rate.

The implementation of the thermally-enhanced in situ remediation technologies of dynamic underground stripping (DUS) and hydrous pyrolysis/oxidation (HPO) directly targeted the source DNAPL, both by accelerating the physical removal with steam stripping and by accelerating the chemical destruction or mineralization with aqueous oxidation (Knauss et al., 1998a; 1998b). During steam injection, creosote components partition and fractionate into the steam or hot water and are mobilized as a function of their physical properties (Wauchope and Getzen, 1972; Peters et al., 1997). When sufficient oxygen is present, organic compounds can also be completely oxidized to carbon dioxide. The rates of oxidation and tendencies to form partially oxidized intermediates are functions of their chemical reactivities. The injection of steam rapidly heated the entire subsurface to its boiling point and most likely greatly reduced the population of the groundwater microbial community. Therefore, the results of the semivolatile organic analyses during the field test were primarily a reflection of the physical and chemical processes that resulted from the steam injections.

The main effect of DUS was the dramatic increase in creosote components extracted from the groundwater. Changes in groundwater chemistry at Wells MW-36 and S-13 correlated with steam injections from Well S-4. Figure 17 shows a plot of total PAH and total oxygenates as a function of time for Well MW-36. MW-36 was initially a clean well, but groundwater samples from it clearly demonstrated the processes of enhanced dissolution and transport of organic compounds due to the subsurface heating. Two maximums occurred in the groundwater creosote concentrations from Well MW-36 during the field test. The total organic concentration reached a maximum approximately one week after each steam pulse. Figure 18 is a similar plot for Well S-13 and shows the same increases in groundwater organics one week after the steam pulses. Increases in the levels of groundwater organics during the field test were observed at other sampling wells, such as S-14 and S-15. It is difficult to relate such increases directly to specific steaming events because of the complex nature of the operations influencing these wells. Wells S-14 and S-15 were affected to varying degrees by numerous steam injections from

multiple injection wells, but, in general, creosote content was definitely enhanced by the steaming operations in these two wells.

In addition to changes in total organic concentrations, the distributions of compounds, relative to each other, in the groundwaters also changed over time. Well MW-36 is an example where the distribution of organics gradually changed during the field test. The histograms in Figure 8 show a moderate progression toward higher molecular weight PAH over time, reflecting the ability of the heated groundwater to mobilize these PAH, which are difficult to remediate under ambient groundwater conditions due to their extremely low aqueous solubilities at lower temperatures. This trend toward an increase in higher molecular weight compounds was also observed in Well S-13 (Figure 9).

The main effect attributed to HPO was the production of partially oxidized intermediate compounds. As reported earlier for the laboratory-based HPO experiments using an actual creosote from this site (Leif et al., 1998), low molecular weight phenols and benzoic acid were formed. These oxygenated compounds represent partially oxidized intermediates formed during the HPO of a complex creosote DNAPL. Figure 17 and Figure 18 show how the concentrations of these same low molecular weight oxygenates changed in response to the steam injections into Well S-4. The levels of total oxygenates reached maximums immediately after both steaming events. Although these compounds cannot be unequivocally attributed to be the products of HPO chemistry, their presence is consistent with the aqueous-phase oxidation expected under these conditions.

The measurement of dissolved oxygen also aided in the evaluation of the HPO process. During the application of HPO, it is critical to know the dissolved-oxygen level in the groundwater, because the fundamental principle of HPO is the ability of hot, oxygenated water to completely mineralize organic compounds to carbon dioxide. As long as there is sufficient dissolved oxygen present, oxidation will occur. Figure 19 is a plot of the dissolved-oxygen measurements from Well MW-36 as a function of time during the field test. A steady decrease in the level of dissolved oxygen was observed during the field test and is consistent with the HPO chemistry, where dissolved oxygen is the oxidant in the chemical oxidation of the aqueous organic species.

Another analytical tool used for evaluating the progress of the HPO remediation process was the measurement of carbon isotope abundances (^{12}C , ^{13}C , and ^{14}C) of the dissolved inorganic carbon (DIC). Because both $^{13}\text{C}/^{12}\text{C}$ and $^{14}\text{C}/^{12}\text{C}$ isotopic signatures of the creosote are distinct relative to the native groundwater, these measurements were used to trace carbon derived from the oxidation of creosote compounds. Figure 20 shows the variations in ^{14}C versus $\delta^{13}\text{C}$ values of DIC in groundwater. The groundwater end-member value was the isotopic signature prior to steaming. The DIC became "older" after steaming, consistent with the production of DIC by the oxidation of "dead" creosote carbon.

In summary, the creosote-derived groundwater contaminants present in the intermediate aquifer of the Southern California Edison Pole Yard exhibited large variations in both compound distributions and contaminant amounts depending on when and where the water samples were taken. The differences in the pre-steam baseline samples can be explained by spatial differences in the compositions of the source DNAPL and proximity to a DNAPL pool. Some of these variations could be the result of physical, chemical, and biological weathering processes that have occurred at the site prior to the injection of steam. The creosote most likely has undergone some alteration, especially in aquifers with high groundwater flow.

Observations consistent with the process of DUS were increases in dissolved organic compound content following increases in groundwater temperature, and enhancements in the relative concentrations of higher molecular weight organics over time. These processes were well documented in the primary sampling wells, MW-36 and S-13.

Observations consistent with the process of HPO were increases in groundwater oxygenate concentrations, decreases in dissolved-oxygen levels, and shifts in carbon isotope abundances in the inorganic carbon pool. Aqueous concentrations of partially oxidized organic compounds (i.e., phenols and benzoic acid) also reached maximum after the steaming events, correlating with the observed increases in PAH concentrations that were a result of DUS. Although oxygenated compounds may be preferentially mobilized by the steam and hot water due to their high aqueous solubilities, their presence is consistent with the process of HPO. Formation of abundant low molecular weight phenols has been observed in laboratory-based HPO experiments using creosote obtained from this site. One oxygenated compound, benzoic acid, was found neither in the creosote nor in the baseline water samples prior to steam injection. This compound is tentatively identified as a partially-oxidized intermediate formed exclusively during HPO. Dissolved oxygen exhibited a steady decrease throughout the test period, consistent with oxygen consumption by hydrocarbon oxidation during HPO. Observed shifts in dissolved- CO_2 carbon-isotope values reflect a contribution from creosote oxidation.

Conclusions

It is clear from the Visalia Field Test at the Southern California Edison Pole Yard that the combined applications of two in situ, thermal-remediation technologies, dynamic underground stripping (DUS) and hydrous pyrolysis/oxidation (HPO), have greatly accelerated the remediation of this creosote-contaminated site. Application of DUS to the site has accelerated the mobilization and removal of creosote. The following observations are evidence for DUS:

- Increases in the concentrations of PAH compounds were observed following the steaming events.
- Increases in the relative amounts of higher molecular weight compounds occurred during the field test.

The application of HPO to the Southern California Edison Pole Yard has accelerated site remediation by oxidizing creosote components. The following observations are evidence supporting HPO:

- Increases in the concentration of partially oxidized organic compounds (i.e., phenol, methyl phenols, benzoic acid) were observed following the steaming events.
- A steady decrease in dissolved oxygen was observed in the intermediate aquifer, consistent with oxygen consumption by creosote oxidation during HPO.
- Carbon isotope shifts in the dissolved inorganic carbon pool coincided with the observed increase in the groundwater oxygenate concentrations. The shifts to "lighter" and "older" isotopic compositions are consistent with creosote oxidation.

From June 20 to August 6, Southern California Edison has reported the following:

- 200,000 lb free product removed (as LNAPL and DNAPL)
- 17,500 lb hydrocarbon collected by activated carbon filtration
- 29,400 lb hydrocarbon burned in boilers
- 45,500 lb of carbon removed as CO₂ produced from creosote oxidation

Acknowledgments

The authors thank Allen Elsholz and Ben Johnson for field support, and Daniel Mew and Fowzia Zaka for analytical support. We also thank the employees of Visalia Southern California Edison Co. and the employees of SteamTech Environmental Services for expert assistance at the site. This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48. Partial support provided by the Southern California Edison Company was greatly appreciated.

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Figures

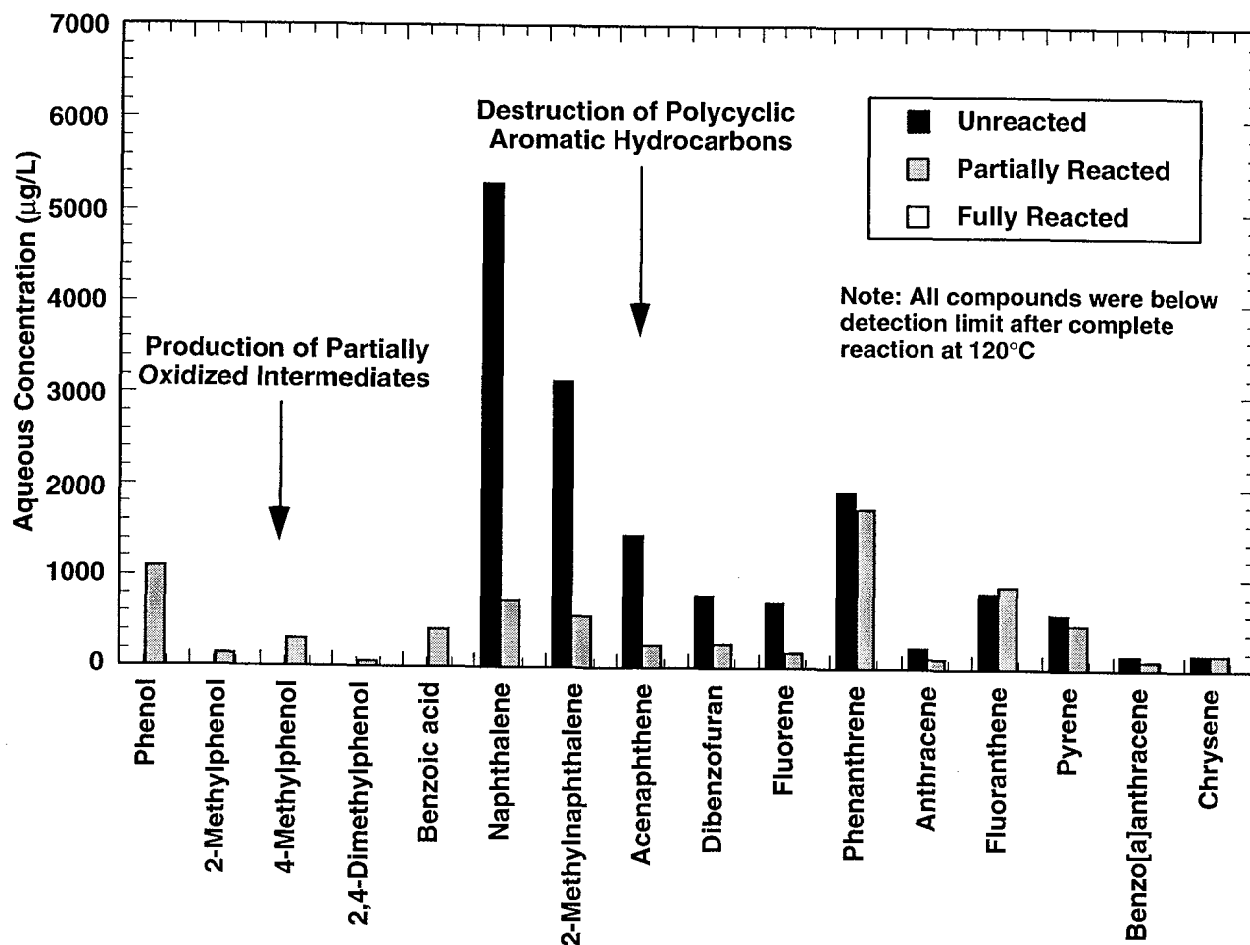


Figure 1. Aqueous concentrations of organic compounds (EPA method 8270A) during laboratory-scale HPO experiment. Starting concentrations are shown in black; partially reacted are shown in gray. Complete destruction of creosote components was achieved at 120°C.

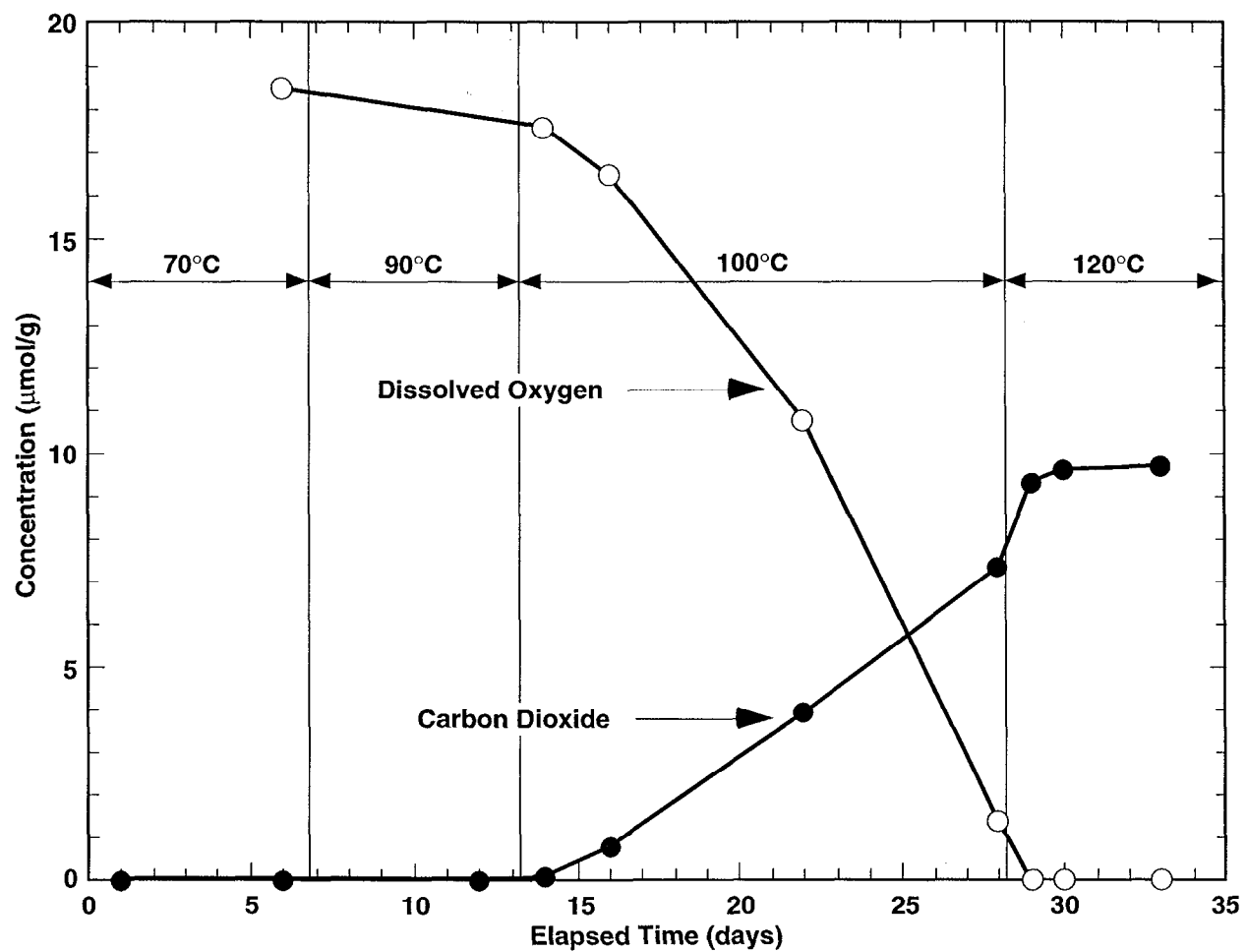


Figure 2. Oxygen consumption and carbon dioxide generation during a laboratory-scale HPO experiment where the reaction temperature was increased from 70°C to 120°C over a duration of 33 days. Complete oxidation of creosote components is shown by the production of CO_2 .

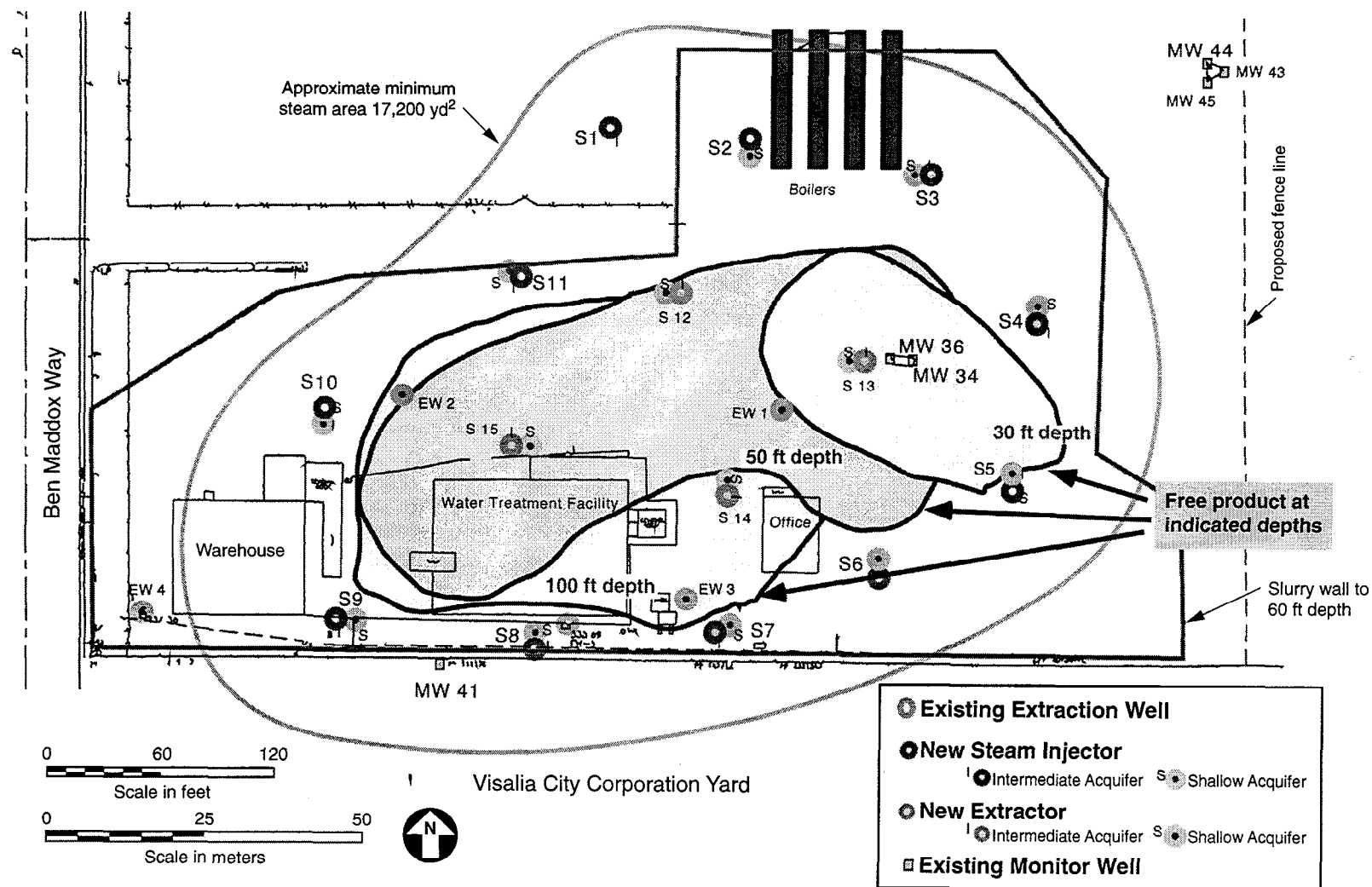


Figure 3. Map of the Southern California Edison Pole Yard showing locations of injection, extraction, and monitoring wells. Injection Well S-4 was used for the HPO demonstration and groundwater chemistry (pH, anions, cations, organic semivolatile compounds) was monitored at Wells S-13 and MW-36 (approximately 90 ft away).

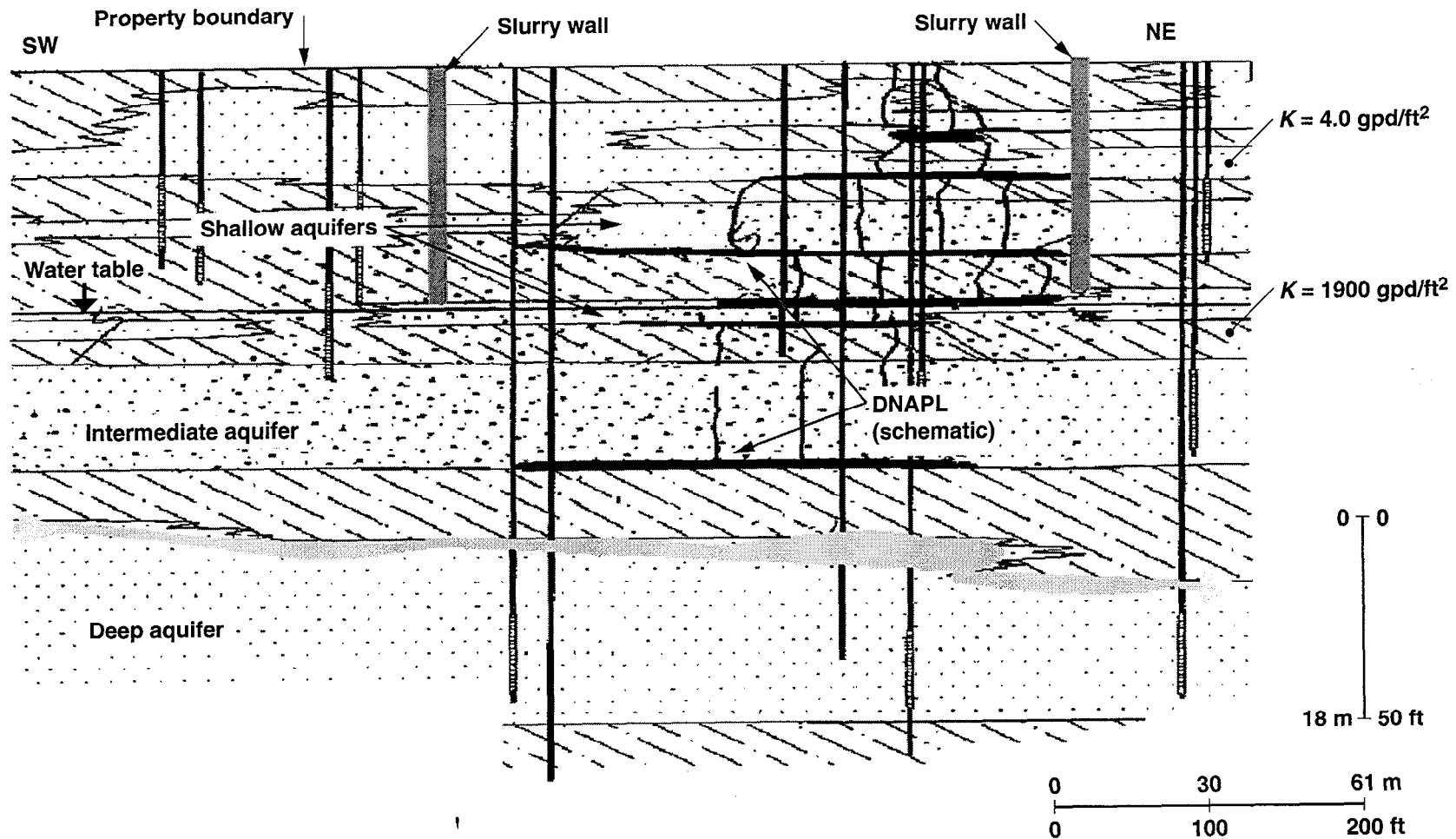


Figure 4. Cross section (approximately northeast-southwest) through the Visalia site, showing the lithology and approximate location of DNAPL contaminant prior to steaming. Depth to water is about 60 ft (the shallow aquifer is unsaturated). Drinking water is produced from the uncontaminated deep aquifer.

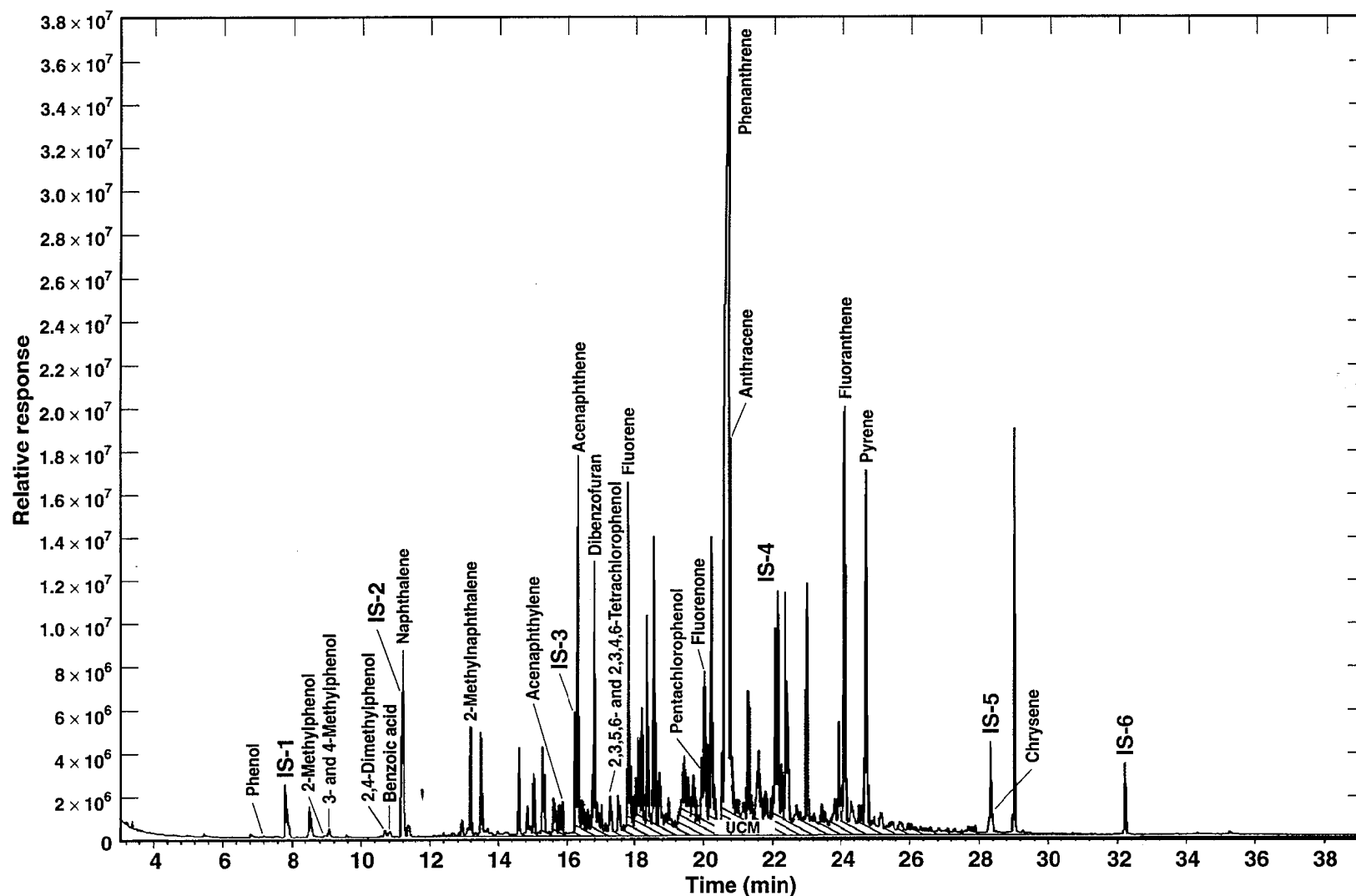


Figure 5. Reconstructed ion chromatogram (RIC) for the GC-MS run of the organic extract from Well S-13 taken on June 19 22:25. The internal standards are labeled IS-1 through IS-6 and quantitated compounds are labeled on the RIC. The unresolved complex mixture (UCM) represents that portion of the extract which remained chromatographically unresolved and not quantitated by GC-MS.

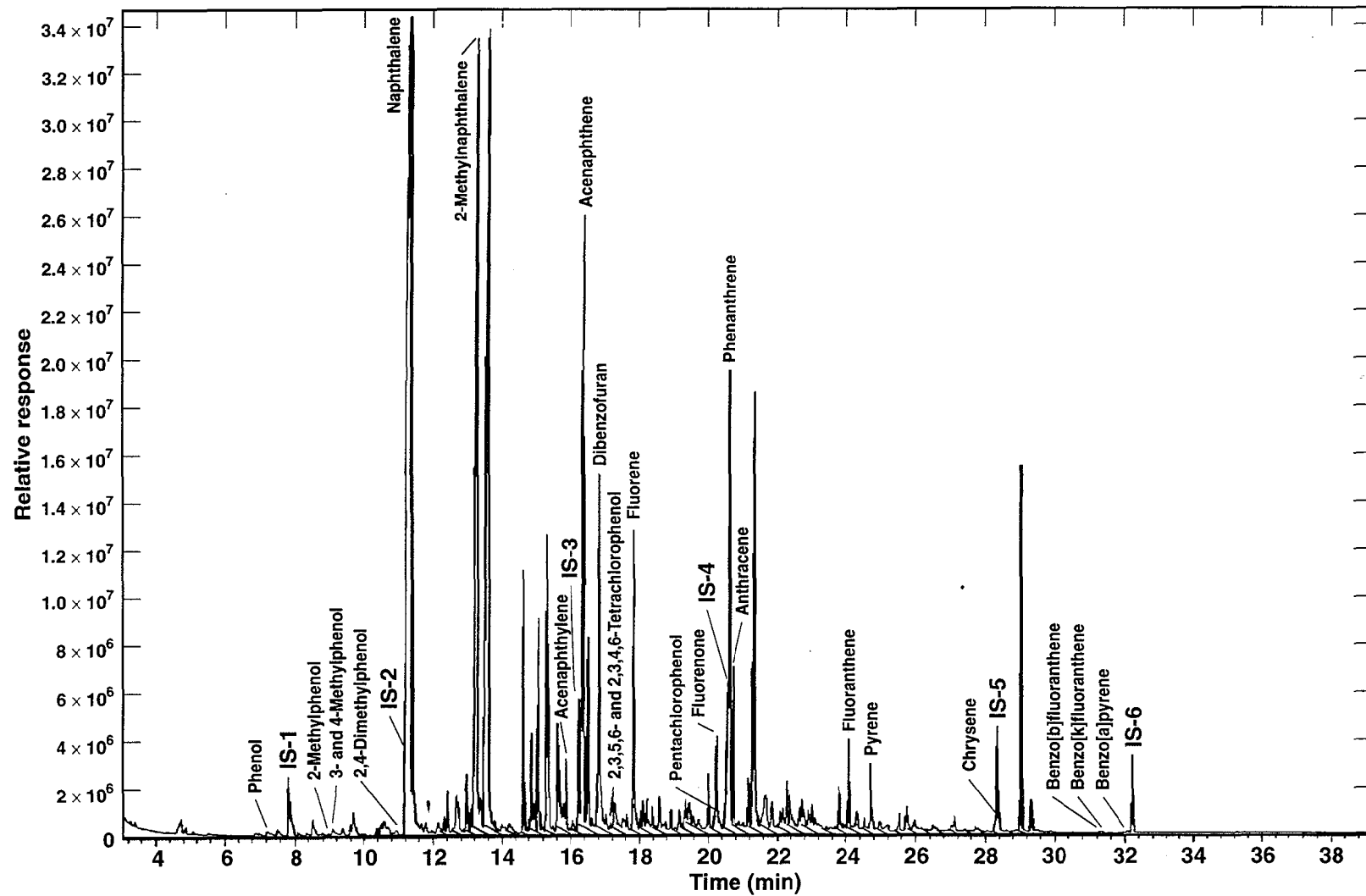


Figure 6. Reconstructed ion chromatogram (RIC) for the GC-MS run of the organic extract from Well S-14 taken on June 17 11:15. The internal standards are labeled IS-1 through IS-6 and quantitated compounds are labeled on the RIC. The unresolved complex mixture (UCM) represents that portion of the extract which remained chromatographically unresolved and not quantitated by GC-MS.

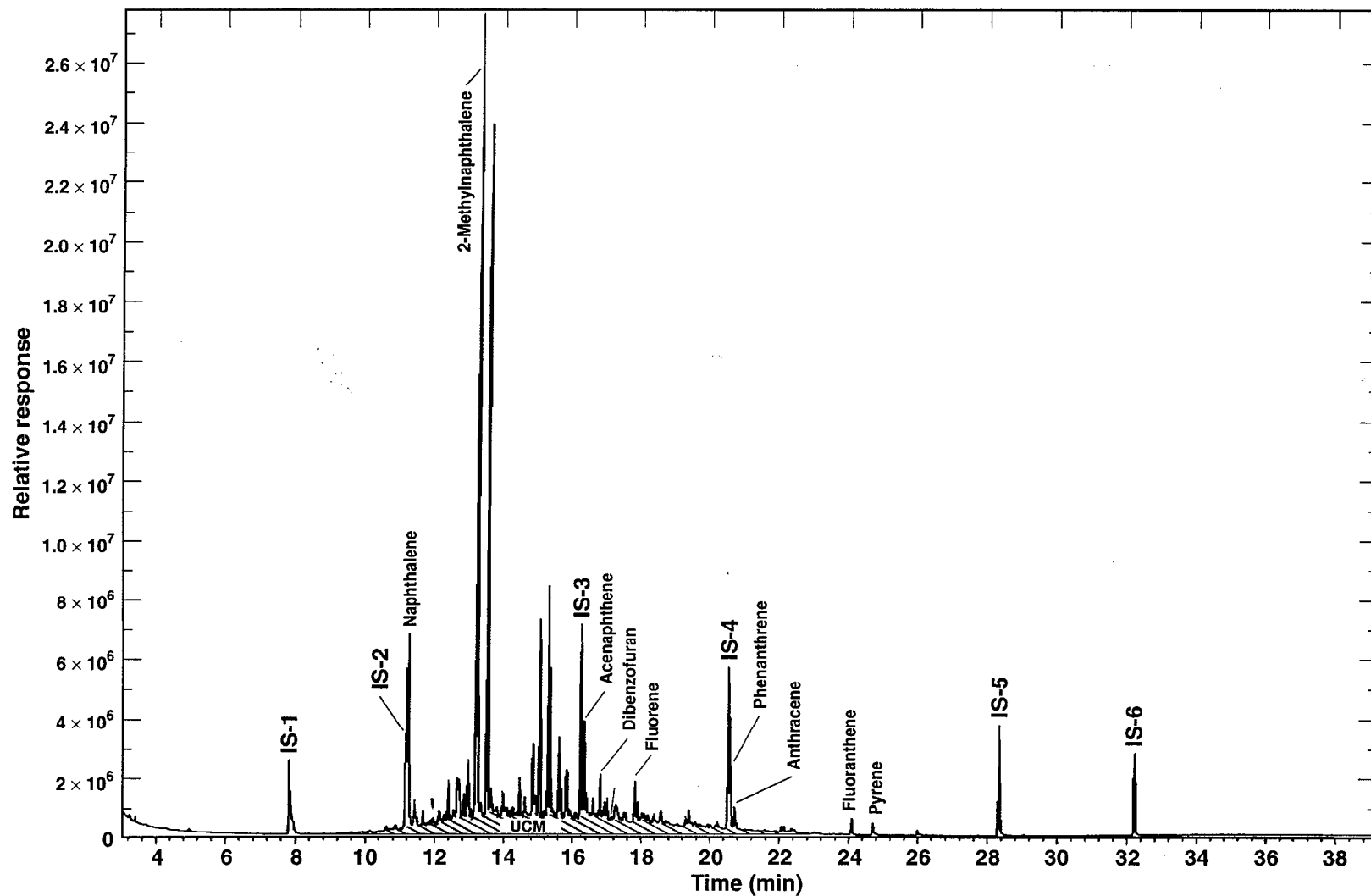


Figure 7. Reconstructed ion chromatogram (RIC) for the GC-MS run of the organic free product from the DAFT taken on July 16. The internal standards are labeled IS-1 through IS-6 and quantitated compounds are labeled on the RIC. The unresolved complex mixture (UCM) represents that portion of the extract which remained chromatographically unresolved and not quantitated by GC-MS.

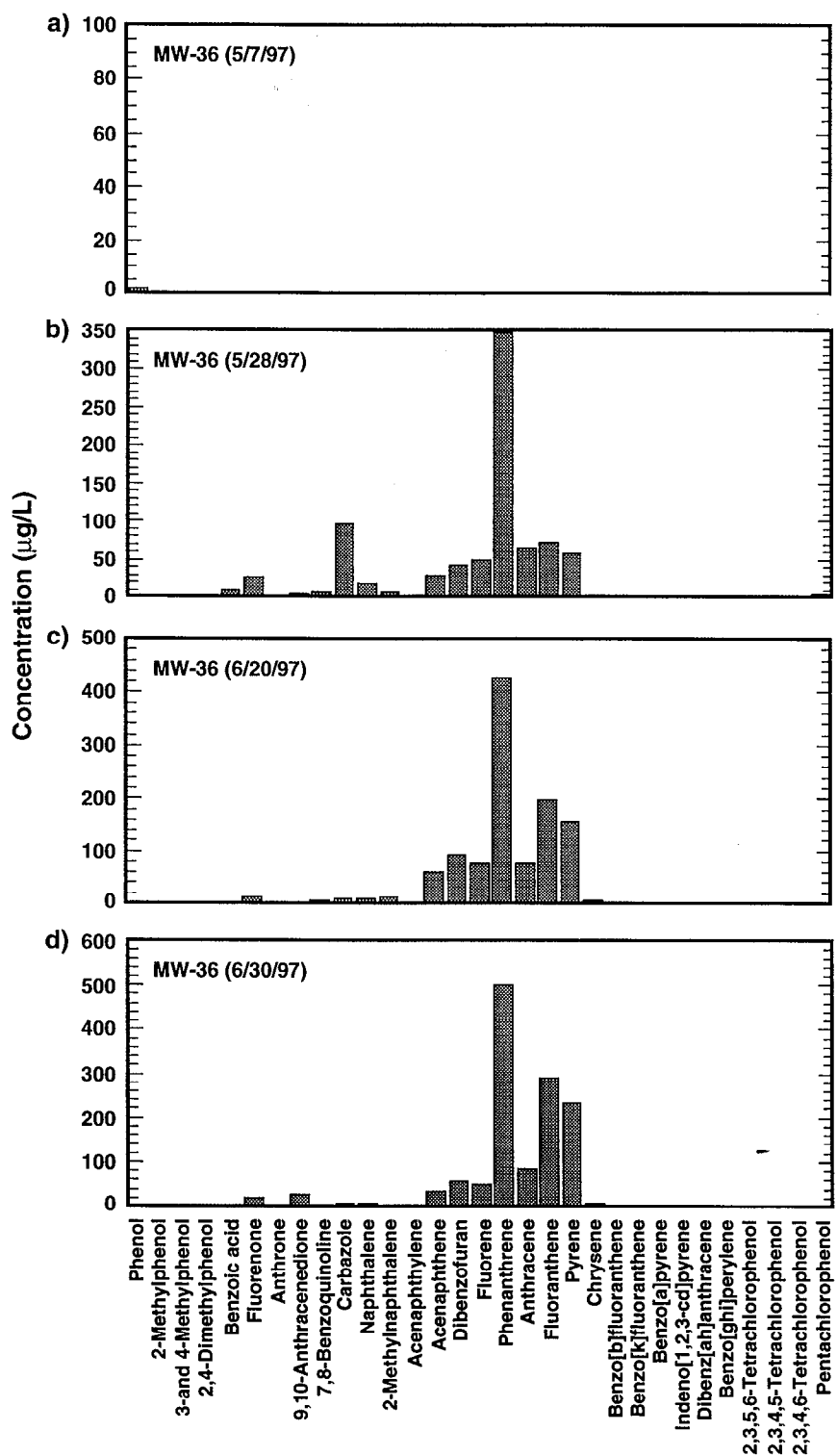


Figure 8. Histograms of the major semivolatile organic compounds present in water sample from Well MW-36: (a) May 7; (b) May 28; (c) June 20; (d) June 30.

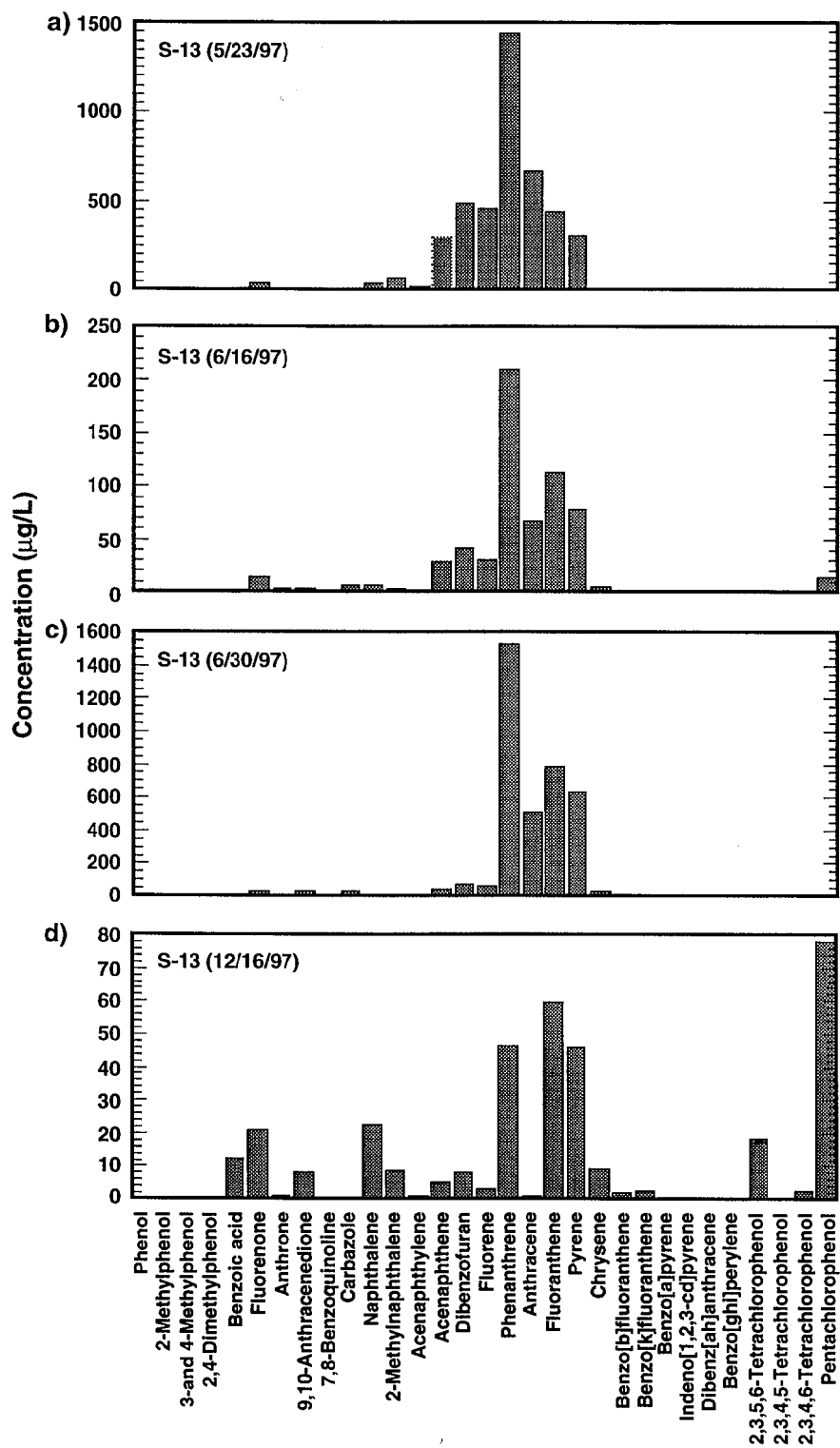


Figure 9. Histograms of the major semivolatile organic compounds present in water samples from Well S-13: (a) May 23; (b) June 16; (c) June 30; (d) December 16.

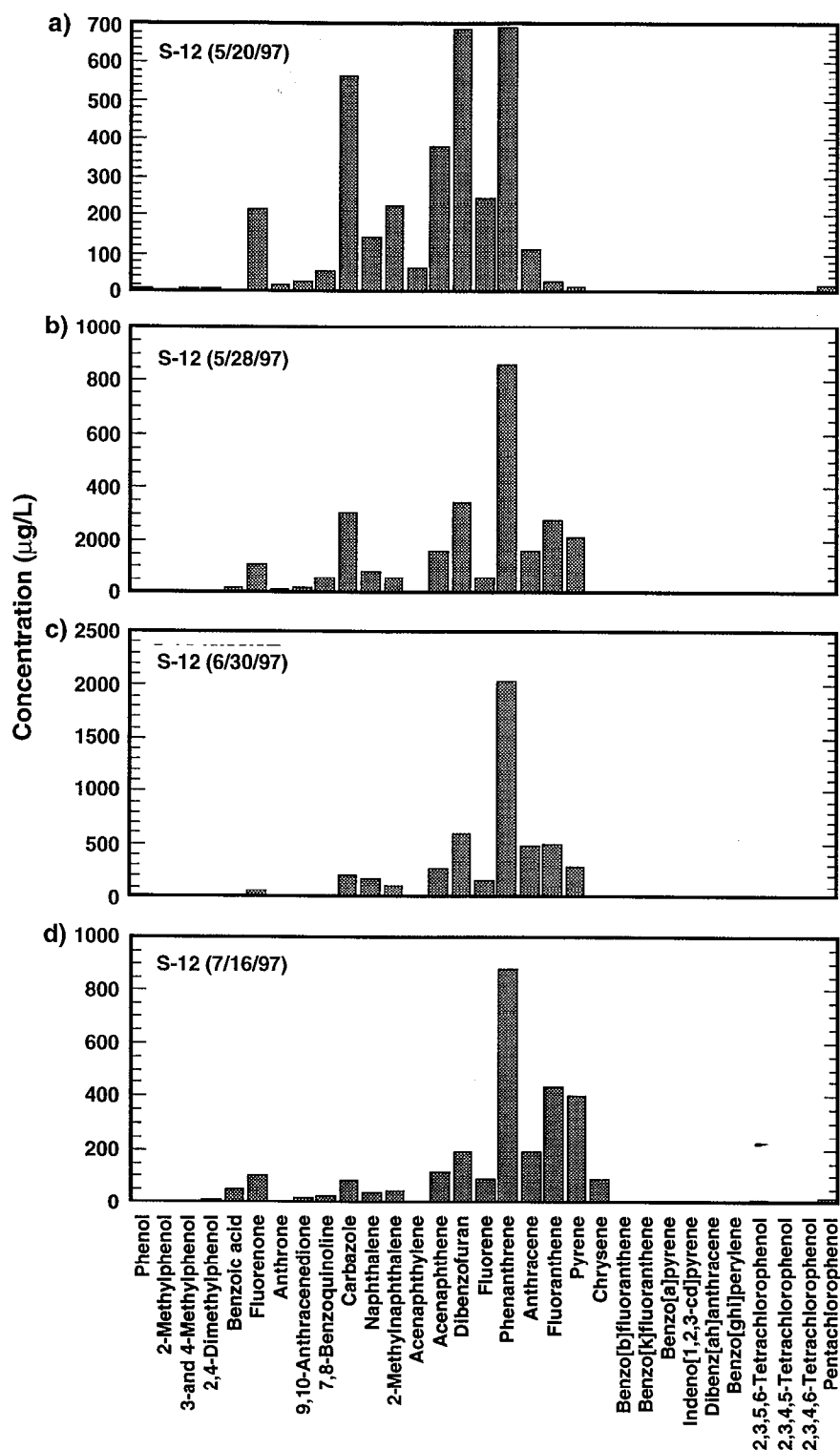


Figure 10. Histograms of the major semivolatile organic compounds present in water samples from Well S-12: (a) May 20; (b) May 28; (c) June 30; (d) July 16.

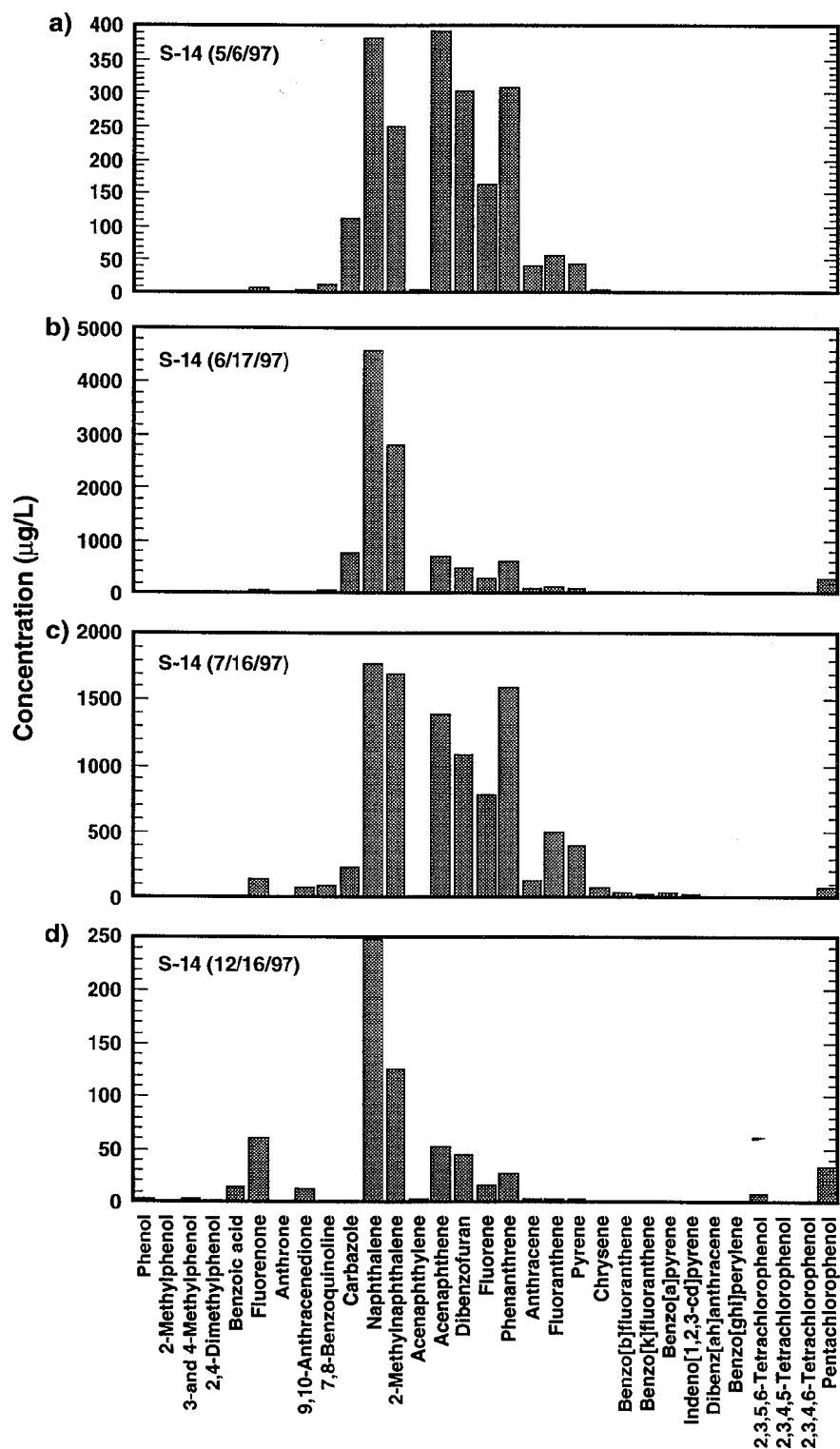


Figure 11. Histograms of the major semivolatile organic compounds present in water samples from Well S-14: (a) May 16; (b) June 17; (c) July 16; (d) December 16.

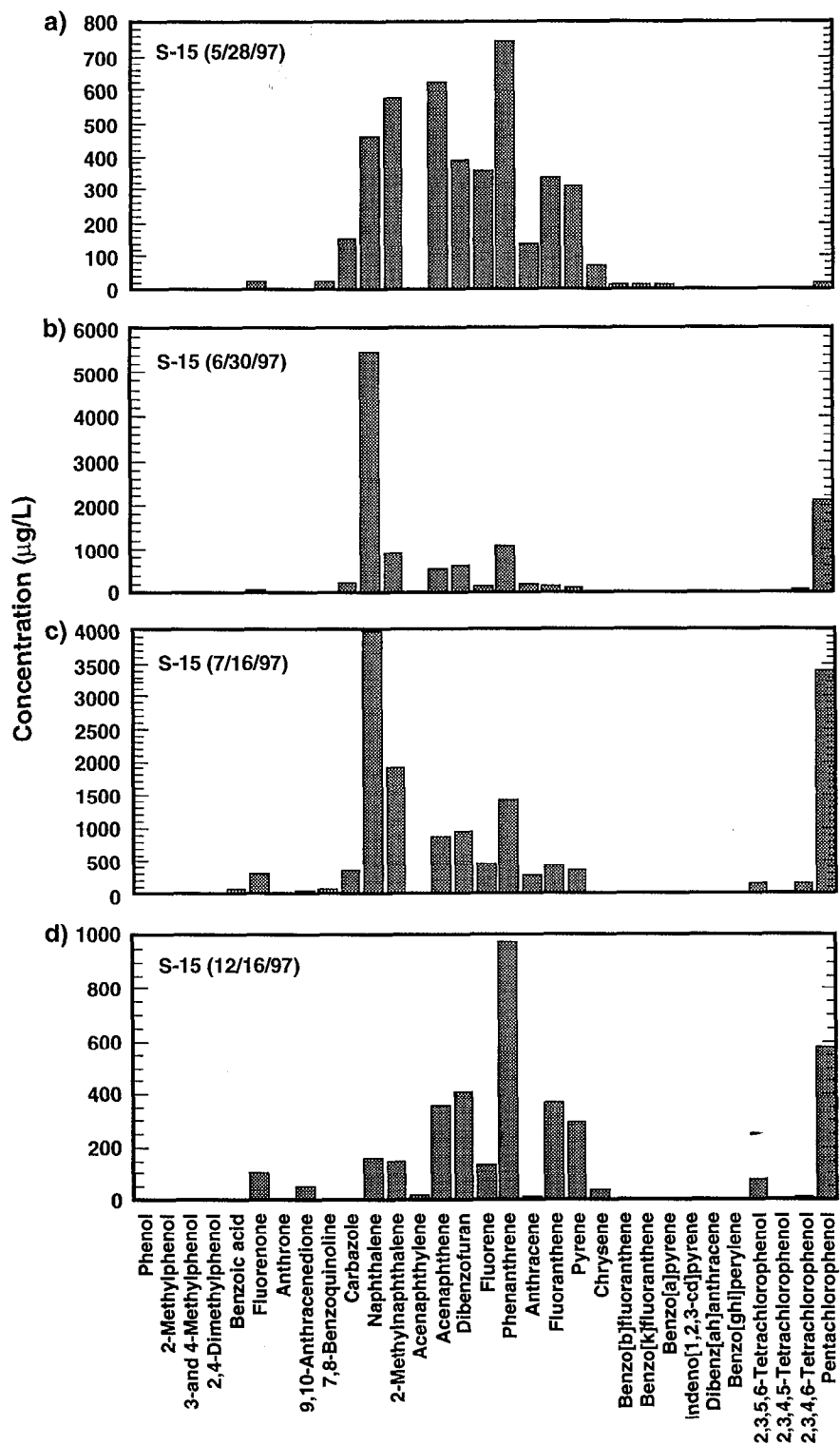


Figure 12. Histograms of the major semivolatile organic compounds present in water samples from Well S-15: (a) May 28; (b) June 30; (c) July 16; (d) December 16.

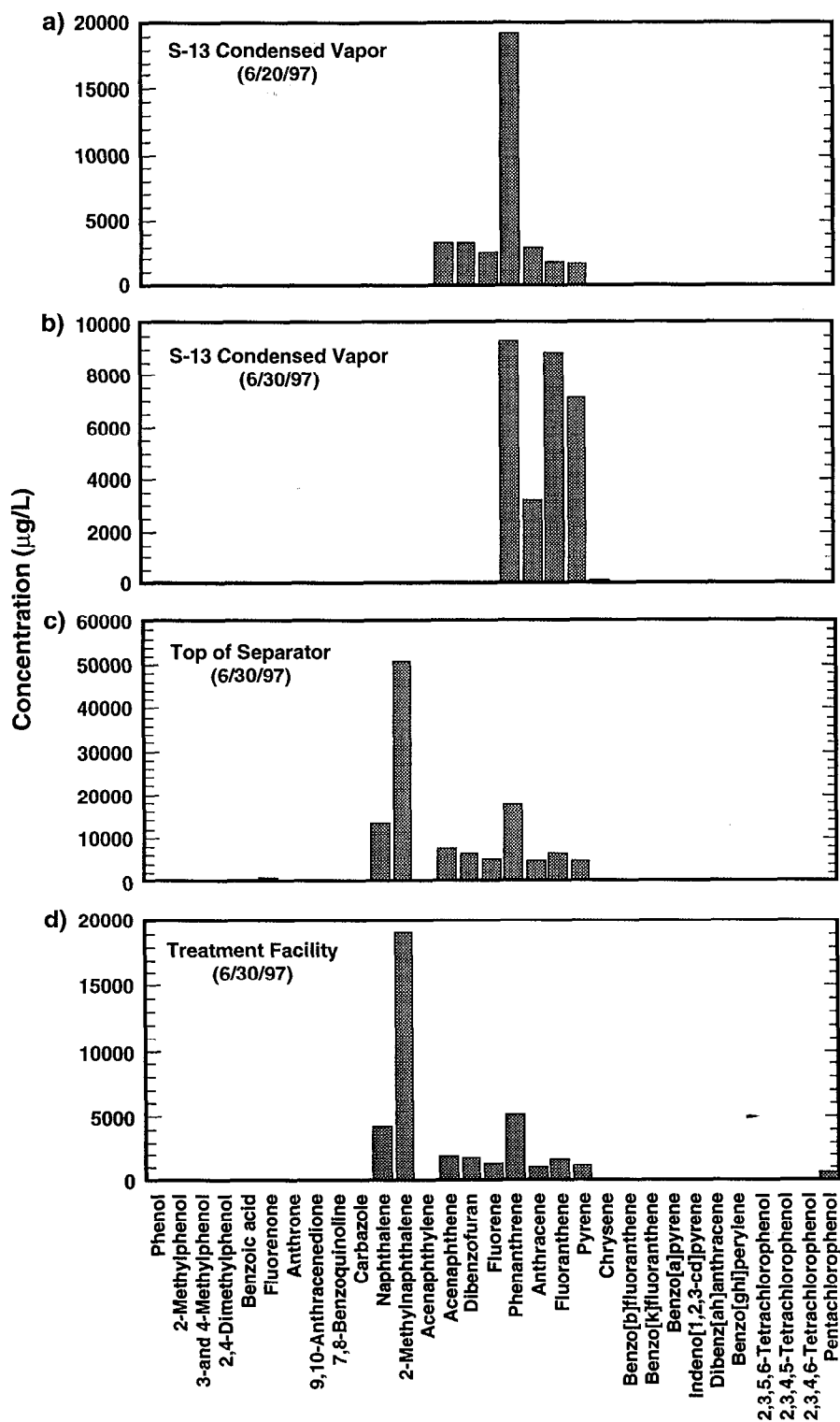


Figure 13. Histograms of the major semivolatile organic compounds present in water samples from miscellaneous sampling sites: (a) S-13 condensed vapor (June 20); (b) S-13 condensed vapor (June 30); (c) Top of separator (June 20); (d) Treatment facility (June 30).

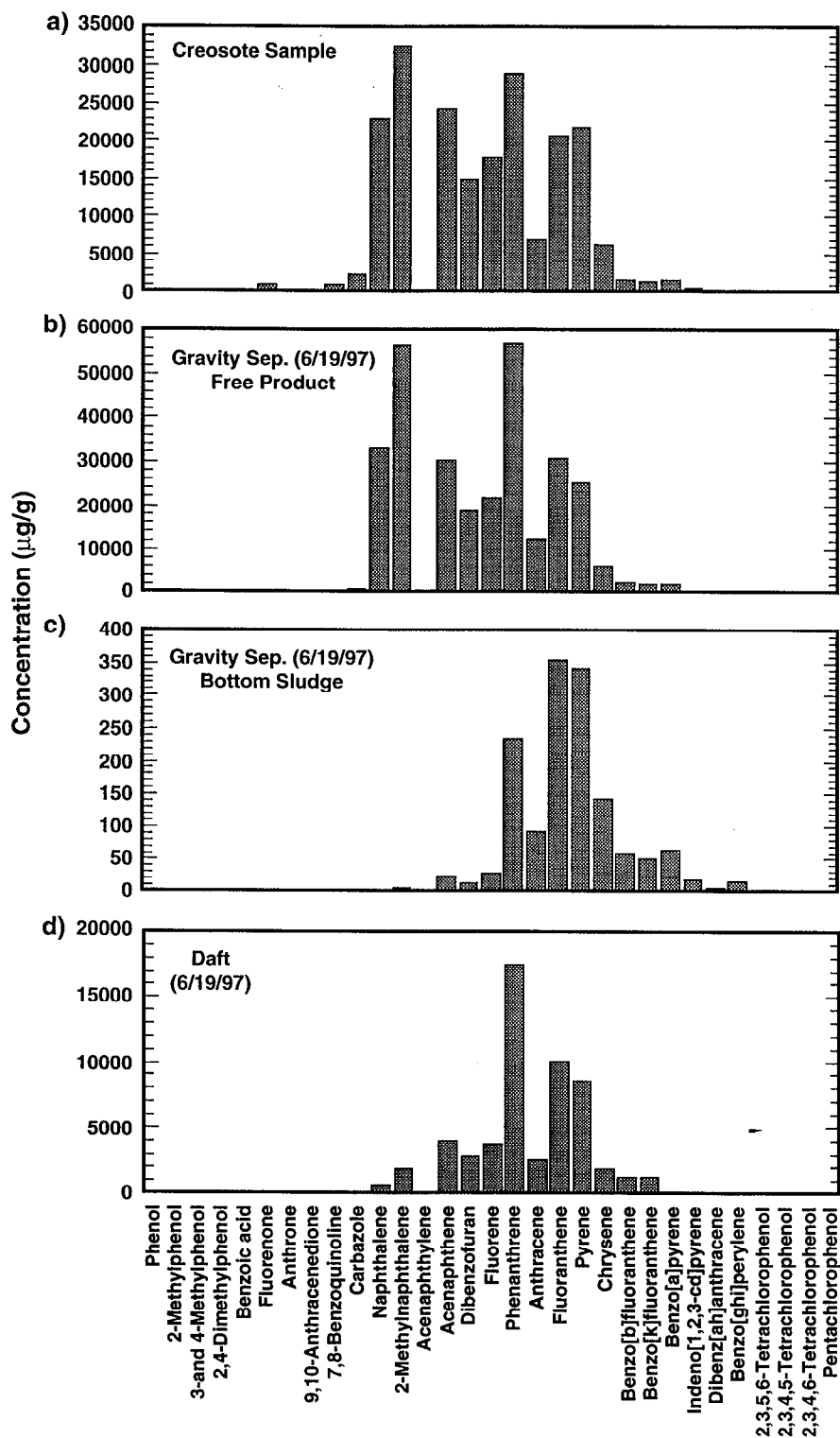


Figure 14. Histograms of the major semivolatile organic compounds present in miscellaneous free product samples: (a) Creosote; (b) Gravity separator (June 19); (c) Gravity separator bottom sludge (June 19); (d) DAFT (June 19).

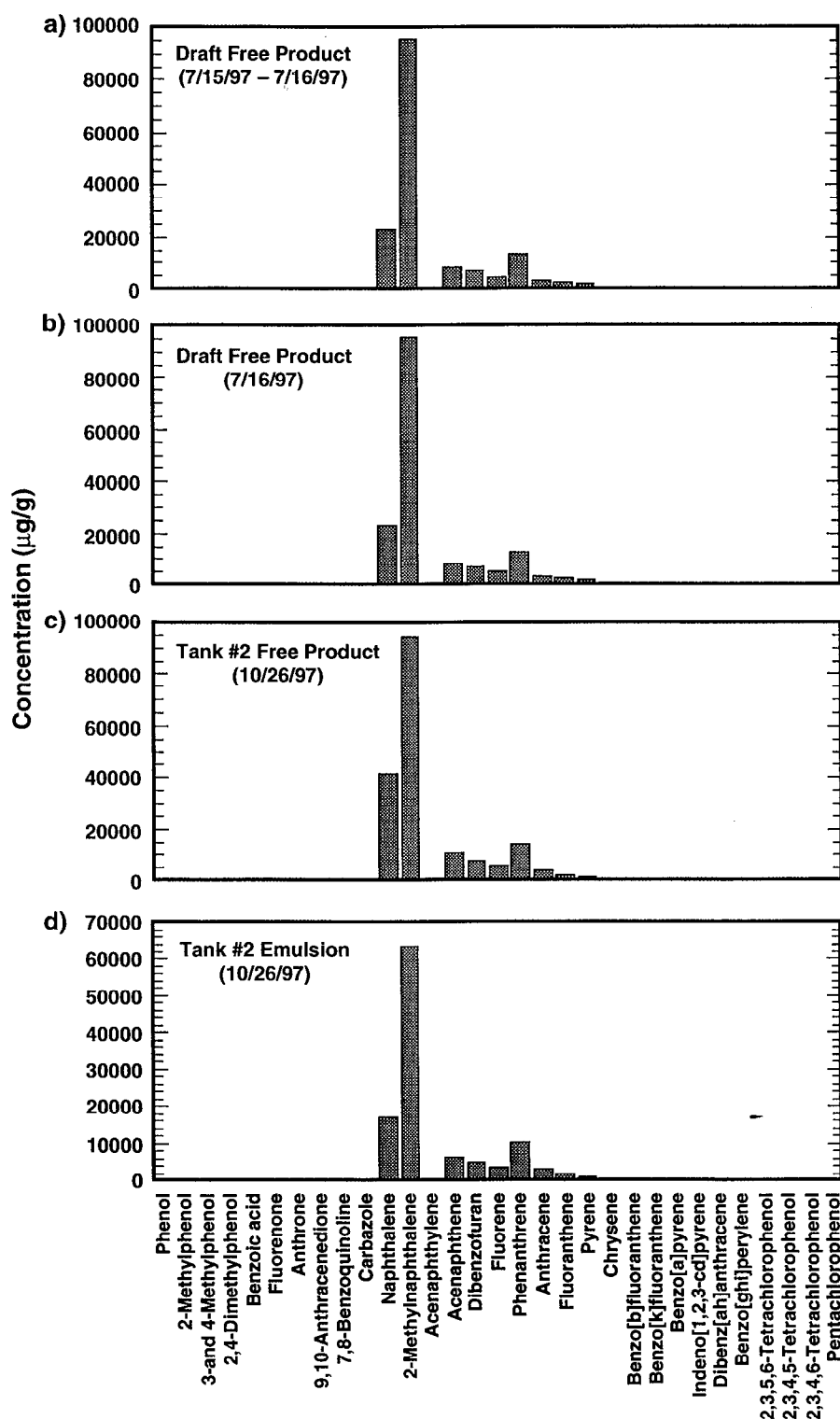


Figure 15. Histograms of the major semivolatile organic compounds present in miscellaneous free product samples: (a) DAFT free product (July 15-16); (b) DAFT free product (July 16); (c) Tank 2 free product (October 26); (d) Tank 2 emulsion (October 26).

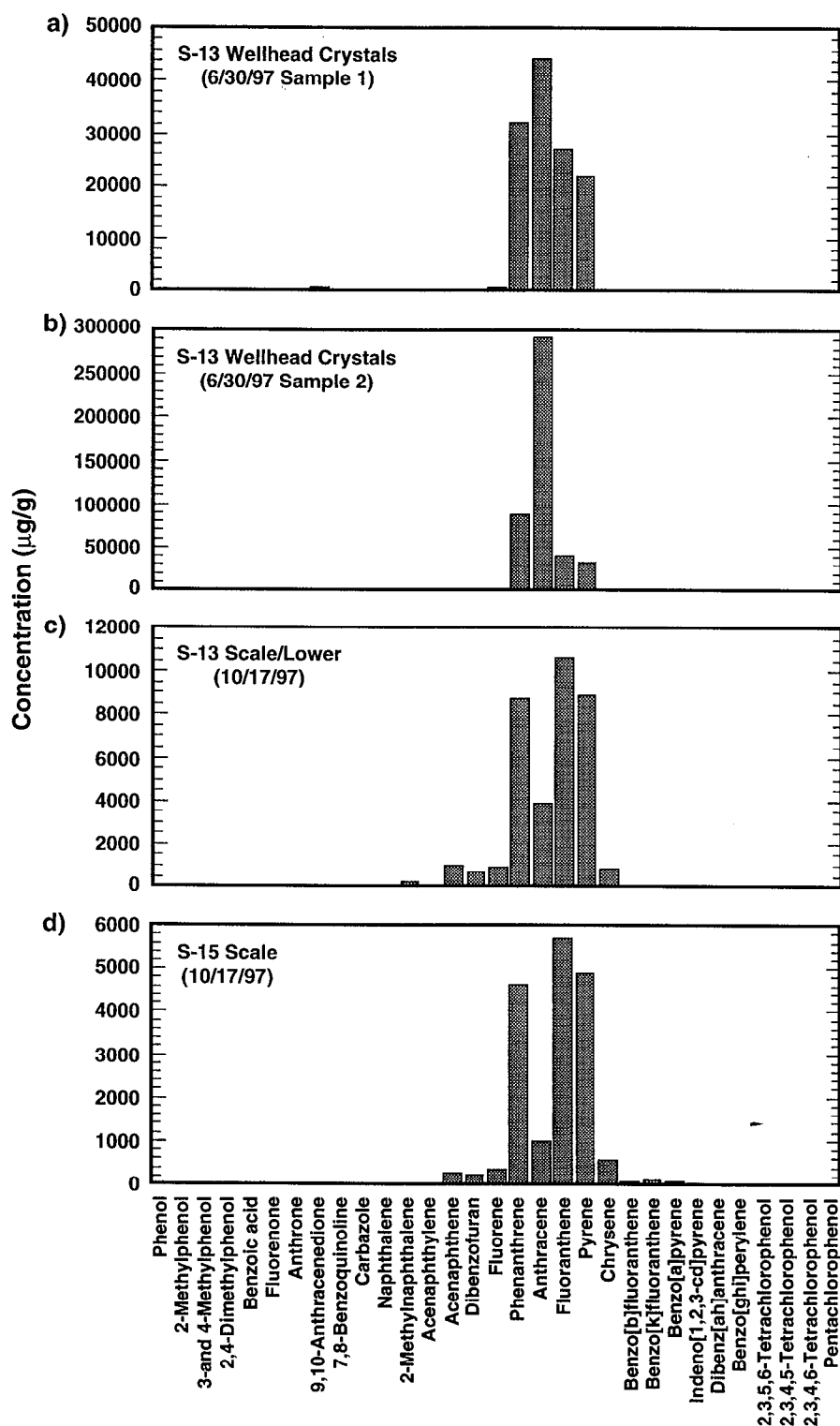


Figure 16. Histograms of the major semivolatile organic compounds present in miscellaneous solid samples: (a) S-13 Wellhead crystals (June 30 Sample 1); (b) S-13 Wellhead crystals (June 30 Sample 2); (c) S-13 scale/lower (October 17); (d) S-15 scale (October 17).

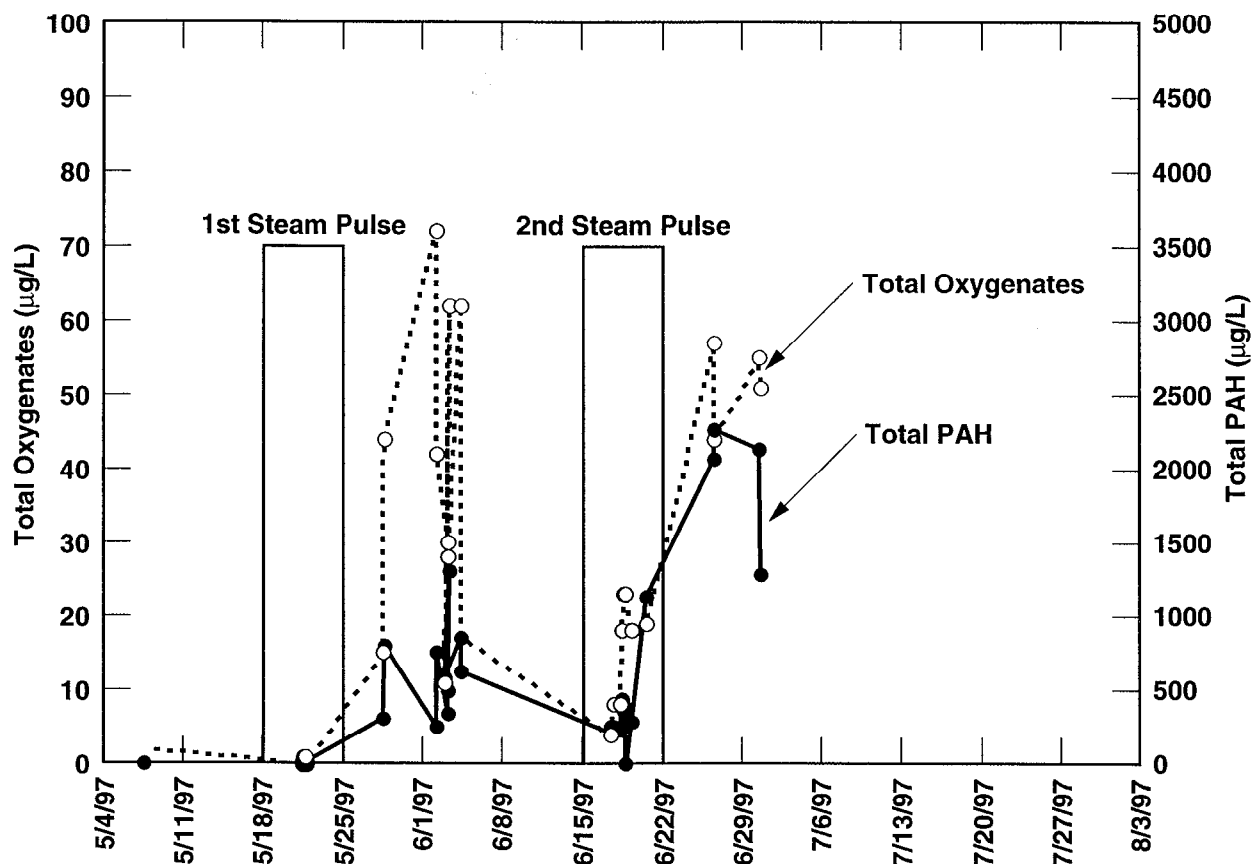


Figure 17. Concentrations of total oxygenates and total PAH (polycyclic aromatic hydrocarbons, EPA Method 8270C) from Well MW-36 during HPO test period. Elevated PAH concentrations reflect enhanced mobilization due to DUS. Oxygenate increases are consistent with partial hydrocarbon oxidation by HPO.

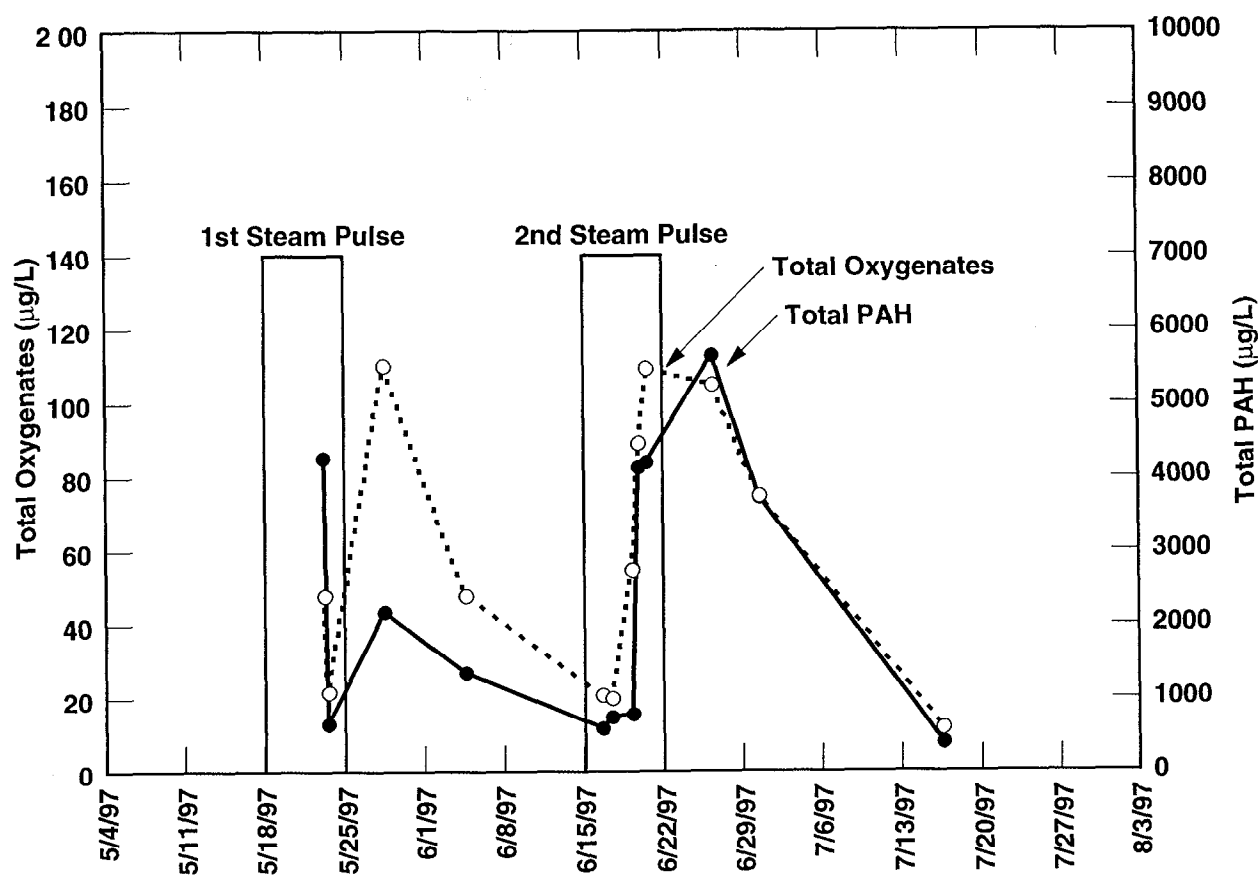


Figure 18. Concentrations of total oxygenates and total PAH (polycyclic aromatic hydrocarbons, EPA Method 8270C) from Well S-13 during HPO test period. Elevated PAH concentrations reflect enhanced mobilization due to DUS. Oxygenate increases are consistent with partial hydrocarbon oxidation by HPO.

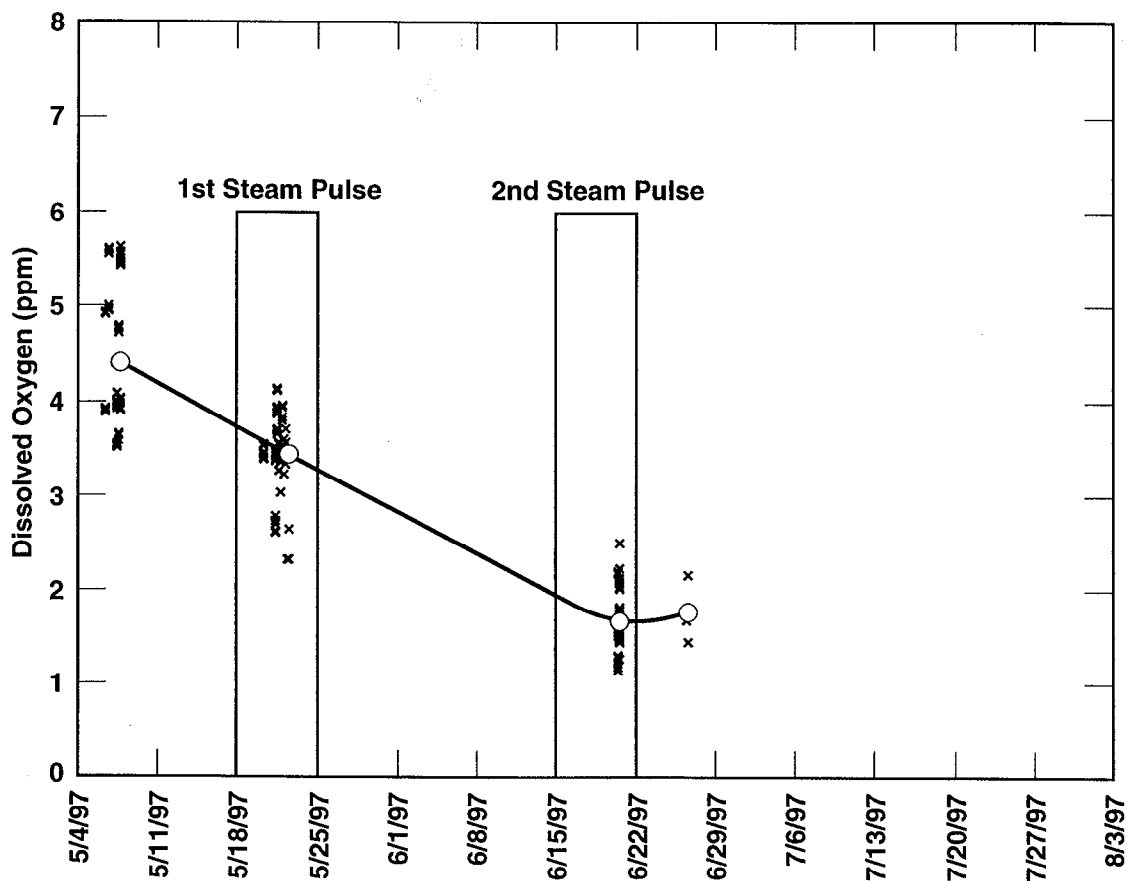


Figure 19. Concentration of dissolved oxygen in Well MW-36 as a function of time during HPO test. Average dissolved oxygen concentrations (open circles) were calculated using the combined values from three different analytical techniques. Dissolved-oxygen levels dropped from 4.4 ppm to 1.7 ppm during the test period.

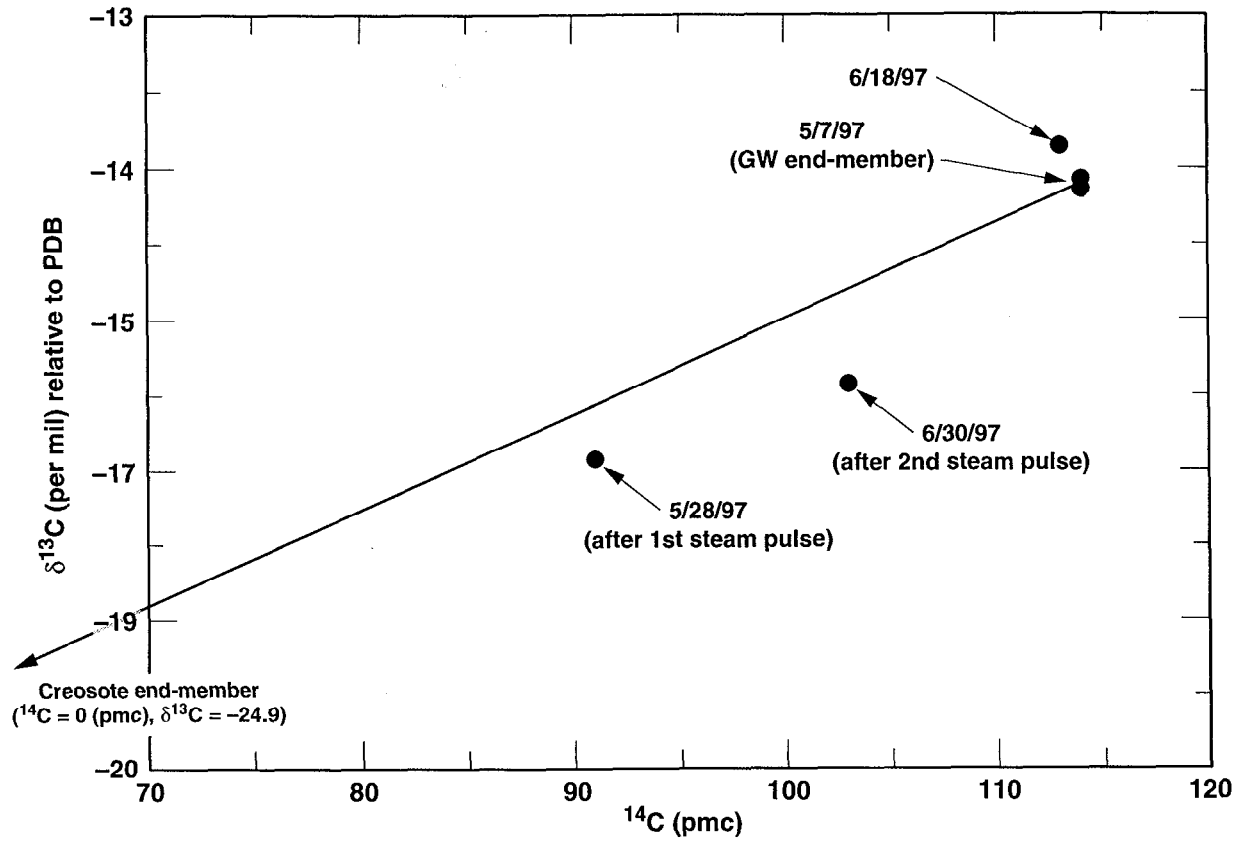
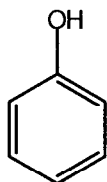


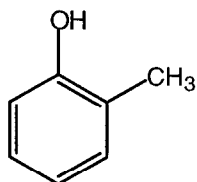
Figure 20. Variations in ^{14}C versus $\delta^{13}\text{C}$ values of dissolved inorganic carbon (DIC) in groundwater. The groundwater end-member value was the isotopic signature prior to steaming. The DIC became "older" after steaming, consistent with the production of DIC by the oxidation of "dead" creosote carbon.

Appendix A: Chemical Structure Diagrams for the Semivolatile Organic Compounds Quantitated by GC-MS

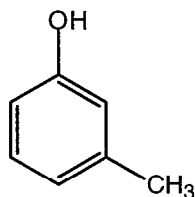
Oxygenated Compounds



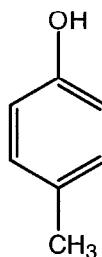
Phenol



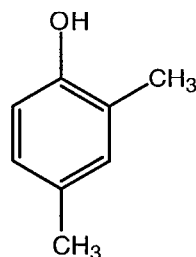
2-Methylphenol



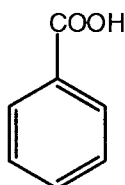
3-Methylphenol



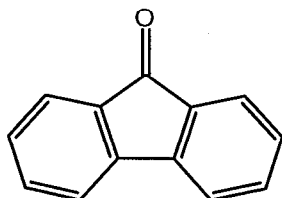
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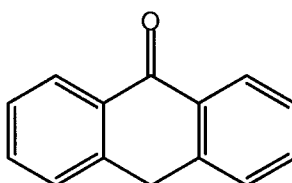
2,4-Dimethylphenol



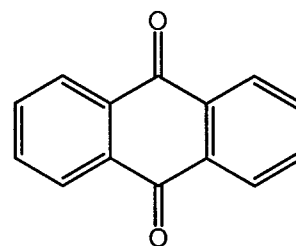
Benzoic Acid



Fluorenone

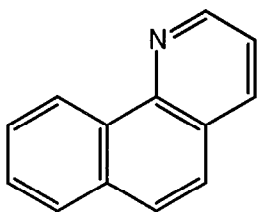


Anthrone

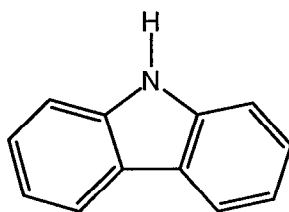


9,10-Anthracenedione

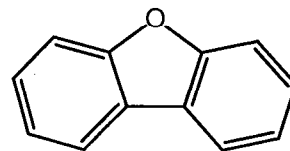
Polycyclic Aromatic Hydrocarbons



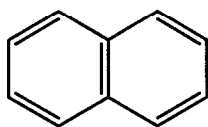
7,8-Benzoquinoline



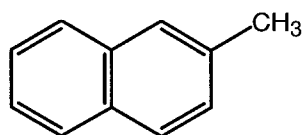
Carbazole



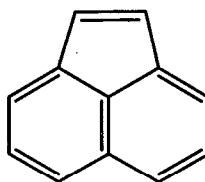
Dibenzofuran



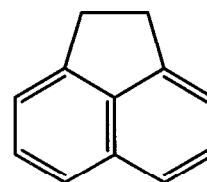
Naphthalene



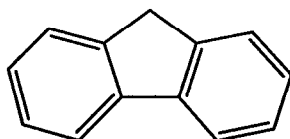
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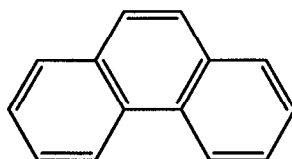
Acenaphthylene



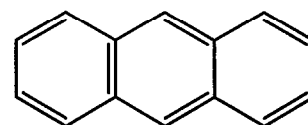
Acenaphthene



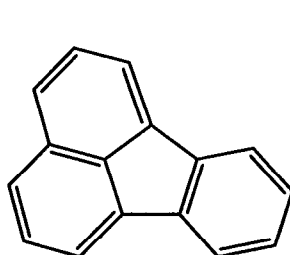
Fluorene



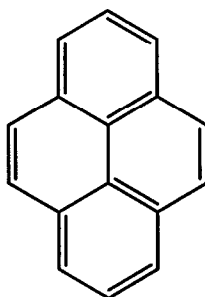
Phenanthrene



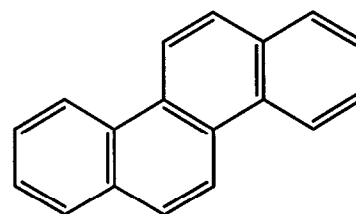
Anthracene



Fluoranthene

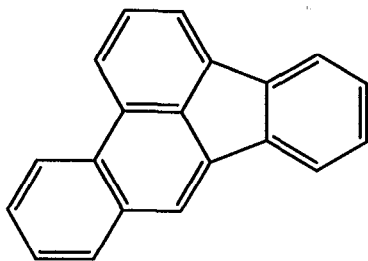


Pyrene

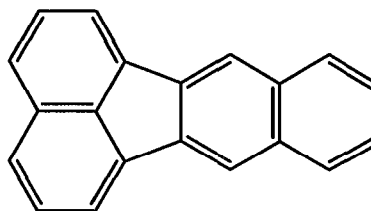


Chrysene

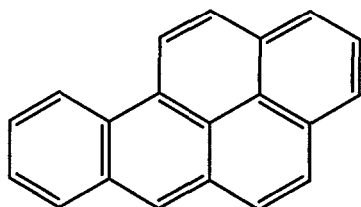
Polycyclic Aromatic Hydrocarbons (continued)



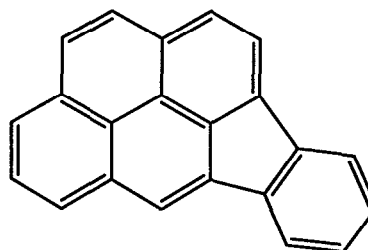
Benzo[b]fluoranthene



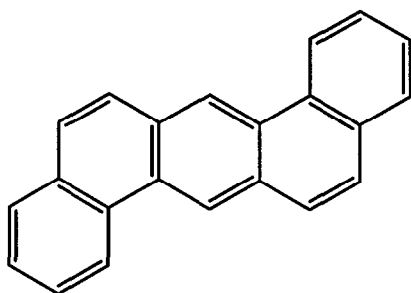
Benzo[k]fluoranthene



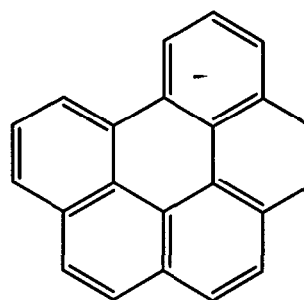
Benzo[a]pyrene



Indeno[1,2,3-cd]pyrene

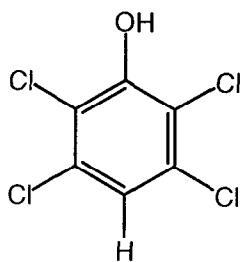


Dibenz[a,h]anthracene

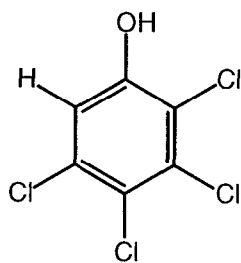


Benzo[ghi]perylene

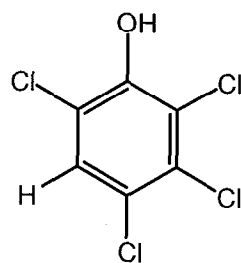
Chlorinated Phenols



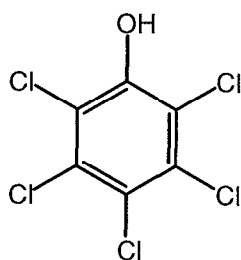
2,3,5,6-Tetrachlorophenol



2,3,4,5-Tetrachlorophenol



2,3,4,6-Tetrachlorophenol



Pentachlorophenol

Appendix B: Tables of Analytical Results of Samples

Table 1. Results of groundwater chemical analyses for Well MW-36 (TIC = total inorganic carbon)

Sample Name	MW-36 (5/7 1400)	MW-36 (5/7 1500)	MW-36 (5/7 1700)	MW-36 (5/21 1100)	MW-36 (5/21 1600)	MW-36 (5/21 1800)	MW-36 (5/21 1850)	MW-36 (5/21 2000)	MW-36 (5/21 2100)	MW-36 (5/28 1508)	MW-36 (5/28 1710)	MW-36 (6/2 0550)	MW-36 (6/2 0603)	MW-36 (6/3 0730)	MW-36 (6/3 0740)	MW-36 (6/3 1045)	MW-36- SPE (6/3 Last Bailed)
Date/Time Sampled	5/7/97 14:00	5/7/97 15:00	5/7/97 17:00	5/21/97 11:00	5/21/97 16:00	5/21/97 18:00	5/21/97 18:50	5/21/97 20:00	5/21/97 21:00	5/28/97 15:08	5/28/97 17:10	6/2/97 5:50	6/2/97 6:03	6/3/97 7:30	6/3/97 7:40	6/3/97 10:45	6/3/97 0:00
pH	7.0	6.9	7.0	7.0	6.9	6.9	7.0	7.0	7.0	6.9	NA	NA	NA	NA	NA	NA	NA
TIC (µg C/g)	53.3	54.1	53.7	51.4	51.7	50.2	49.2	48.9	48.9	25.5	NA	NA	NA	NA	NA	NA	NA
Cations (µg/g)																	
Al	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA
B	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.20	NA	NA	NA	NA	NA	NA	NA
Ca	77.17	77.04	74.89	77.77	78.91	77.25	77.22	79.51	80.00	34.50	NA	NA	NA	NA	NA	NA	NA
Cr	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA
Cu	ND	ND	ND	ND	ND	0.04	0.02	0.02	ND	0.01	NA	NA	NA	NA	NA	NA	NA
Fe	0.02	ND	ND	0.10	ND	0.13	0.13	0.13	1.26	8.96	NA	NA	NA	NA	NA	NA	NA
K	1.94	1.18	1.60	1.87	2.08	1.97	1.90	1.86	1.70	1.90	NA	NA	NA	NA	NA	NA	NA
Mg	13.72	13.87	13.42	13.81	13.99	13.86	13.76	13.87	14.40	5.62	NA	NA	NA	NA	NA	NA	NA
Mn	ND	ND	ND	ND	ND	ND	ND	ND	0.02	0.13	NA	NA	NA	NA	NA	NA	NA
Na	17.86	17.35	17.38	17.80	18.57	18.00	18.08	17.70	18.90	20.10	NA	NA	NA	NA	NA	NA	NA
S	1.81	1.80	1.74	1.86	1.84	1.88	1.83	1.83	11.40	6.20	NA	NA	NA	NA	NA	NA	NA
Si	14.15	14.50	14.16	14.44	14.51	14.50	14.33	14.41	14.40	9.58	NA	NA	NA	NA	NA	NA	NA
Sr	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.55	0.26	NA	NA	NA	NA	NA	NA	NA
Zn	ND	ND	ND	ND	ND	ND	ND	ND	0.04	0.06	NA	NA	NA	NA	NA	NA	NA
Anions (µg/g)																	
Fluoride	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	18.1	17.2	17.4	18.1	18.7	18.8	18.8	18.4	18.0	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA
Bromide	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate	35.1	33.6	34.8	39.5	39.4	39.4	37.7	41.0	37.4	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	31.5	30.5	35.0	34.8	33.8	30.8	35.1	40.0	39.1	NA	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organics (µg/L)																	
Phenol	2.0	NA	NA	ND	0.7	0.7	ND	ND	ND	1.6	2.0	3.3	ND	ND	ND	1.8	ND
2-Methylphenol	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND
3- and 4-Methylphenol	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	0.9	3.4	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Sample Name	MW-36 (5/7 1400)	MW-36 (5/7 1500)	MW-36 (5/7 1700)	MW-36 (5/21 1100)	MW-36 (5/21 1600)	MW-36 (5/21 1800)	MW-36 (5/21 1850)	MW-36 (5/21 2000)	MW-36 (5/21 2100)	MW-36 (5/28 1508)	MW-36 (5/28 1710)	MW-36 (6/2 0550)	MW-36 (6/2 0603)	MW-36 (6/3 0730)	MW-36 (6/3 0740)	MW-36 (6/3 1045)	MW-36- SPE (6/3 Last Bailed)
Date/Time Sampled	5/7/97 14:00	5/7/97 15:00	5/7/97 17:00	5/21/97 11:00	5/21/97 16:00	5/21/97 18:00	5/21/97 18:50	5/21/97 20:00	5/21/97 21:00	5/28/97 15:08	5/28/97 17:10	6/2/97 5:50	6/2/97 6:03	6/3/97 7:30	6/3/97 7:40	6/3/97 10:45	6/3/97 0:00
Benzoic acid	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	8.2	48.3	ND	ND	ND	16.9	ND
Fluorenone	ND	NA	NA	0.4	0.6	0.5	0.6	0.5	0.4	11.6	27.4	15.2	33.8	26.4	24.3	37.7	11.4
Anthrone	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.0	ND	ND	ND	ND
9,10-Anthracenedione	ND	NA	NA	ND	ND	ND	ND	ND	ND	2.1	4.7	2.0	5.2	3.9	3.6	5.8	ND
7,8-Benzoquinoline	ND	NA	NA	ND	ND	ND	ND	ND	ND	3.0	6.1	4.1	4.4	ND	3.4	5.4	ND
Carbazole	ND	NA	NA	ND	ND	ND	ND	ND	ND	43.3	96.1	45.8	78.0	45.1	63.2	80.1	ND
Naphthalene	ND	NA	NA	5.2	4.8	4.5	4.5	5.4	4.7	14.6	17.6	13.0	33.6	24.2	25.2	40.9	17.1
2-Methylnaphthalene	ND	NA	NA	ND	ND	ND	ND	ND	ND	8.9	6.6	6.3	9.5	8.6	7.7	15.8	ND
Acenaphthylene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	1.8	1.5	2.3	ND	ND	ND	ND
Acenaphthene	ND	NA	NA	ND	4.1	4.1	4.7	ND	3.9	13.9	28.7	16.4	35.0	22.3	24.4	48.5	ND
Dibenzofuran	ND	NA	NA	ND	ND	ND	ND	ND	ND	18.5	43.1	20.3	41.5	26.1	31.3	49.0	ND
Fluorene	ND	NA	NA	ND	ND	ND	ND	ND	ND	17.6	49.7	18.9	41.3	24.2	30.1	50.8	24.1
Phenanthrene	ND	NA	NA	2.9	5.8	4.6	5.4	ND	5.1	127.5	347.5	90.1	341.3	144.3	223.8	565.0	300.4
Anthracene	ND	NA	NA	0.2	0.4	0.4	0.4	ND	0.3	19.0	65.3	14.7	52.1	20.5	35.0	96.7	43.0
Fluoranthene	ND	NA	NA	ND	ND	ND	ND	ND	ND	21.6	72.0	9.8	65.6	14.3	24.6	184.2	115.4
Pyrene	ND	NA	NA	ND	ND	ND	ND	ND	ND	17.3	58.3	7.5	49.6	10.2	19.5	162.9	78.5
Chrysene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11.1	ND
Benzo[b]fluoranthene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7	ND
Benzo[k]fluoranthene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	ND
Indeno[1,2,3-cd]pyrene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[ah]anthracene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[ghi]perylene	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,5-Tetrachlorophenol	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	0.4	NA	NA	ND	ND	ND	ND	ND	0.2	2.6	4.9	5.0	4.4	2.7	3.0	4.2	ND
Total Oxygenates (µg/L)	2	-	-	0	1	1	1	0	0	15	44	72	42	30	28	62	11
Total PAH (µg/L)	0	-	-	8	15	14	15	5	14	305	793	248	754	340	488	1311	579
Total Cl-Phenols (µg/L)	0	-	-	0	0	0	0	0	0	3	5	5	4	3	3	4	0
Total GC-MS (µg/L)	2	-	-	9	16	15	16	6	15	323	841	326	801	373	519	1378	590
% Oxygenates	81.6	-	-	4.2	7.5	8.1	4.0	7.8	3.0	4.7	5.2	22.2	5.2	8.1	5.4	4.5	1.9

Table 1 (continued). Results of groundwater chemical analyses for Well MW-36

Sample Name	MW-36 (6/4 0902)	MW-36 (6/4 1114)	MW-36 (6/17 1305)	MW-36 (6/17 1330)	MW-36 (6/17 1720)	MW-36 (6/18 0940)	MW-36 (6/18 1330)	MW-36 (6/18 1630)	MW-36 (6/18 1835)	MW-36 (6/18 2030)	MW-36 (6/19 0805)	MW-36 (6/19 1420)	MW-36 (6/19 1830)	MW-36 (6/19 2255)	MW-36 (6/20 0955)	MW-36 (6/20 1200)	MW-36 (6/20 1345)
Date/Time Sampled	6/4/97 9:02	6/4/97 11:14	6/17/97 13:05	6/17/97 13:30	6/17/97 17:20	6/18/97 9:40	6/18/97 13:30	6/18/97 16:30	6/18/97 18:35	6/18/97 20:30	6/19/97 8:05	6/19/97 14:20	6/19/97 18:30	6/19/97 22:55	6/20/97 9:55	6/20/97 12:00	6/20/97 13:45
pH	NA	NA	7.0	7.0	7.0	7.0	6.8	6.7	6.8	6.7	6.8	6.9	6.8	6.8	6.8	6.9	6.9
TIC (µg C/g)	NA	NA	46.6	46.0	47.0	49.3	47.5	47.6	46.3	48.2	48.2	49.8	48.5	48.3	51.7	50.4	50.5
Cations (µg/g)																	
Al	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ca	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cu	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
K	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mn	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Na	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Si	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zn	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anions (µg/g)																	
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organics (µg/L)																	
Phenol	1.8	ND	ND	ND	ND	ND	ND	0.3	0.3	NA	ND	NA	NA	NA	NA	NA	0.3
2-Methylphenol	ND	ND	ND	ND	ND	ND	ND	0.6	0.1	NA	ND	NA	NA	NA	NA	NA	ND
3- and 4-Methylphenol	ND	ND	ND	ND	ND	ND	ND	0.6	0.5	NA	ND	NA	NA	NA	NA	NA	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	0.1	0.1	NA	ND	NA	NA	NA	NA	NA	ND
Benzoic acid	13.3	ND	ND	ND	ND	ND	ND	ND	0.0	NA	ND	NA	NA	NA	NA	NA	ND
Fluorenone	30.7	17.2	4.0	4.4	5.7	6.0	14.9	17.1	18.2	NA	9.9	NA	NA	NA	NA	NA	14.2
Anthrone	3.0	ND	ND	ND	ND	0.5	ND	1.2	1.3	NA	0.8	NA	NA	NA	NA	NA	1.1
9,10-Anthracenedione	13.2	ND	ND	ND	2.0	1.4	3.0	3.5	2.7	NA	7.4	NA	NA	NA	NA	NA	3.7
7,8-Benzoquinoline	4.3	ND	ND	ND	ND	0.9	1.9	5.0	5.6	NA	1.8	NA	NA	NA	NA	NA	5.8

Sample Name	MW-36 (6/4 0902)	MW-36 (6/4 1114)	MW-36 (6/17 1305)	MW-36 (6/17 1330)	MW-36 (6/17 1720)	MW-36 (6/18 0940)	MW-36 (6/18 1330)	MW-36 (6/18 1630)	MW-36 (6/18 1835)	MW-36 (6/18 2030)	MW-36 (6/19 0805)	MW-36 (6/19 1420)	MW-36 (6/19 1830)	MW-36 (6/19 2255)	MW-36 (6/20 0955)	MW-36 (6/20 1200)	MW-36 (6/20 1345)
Date/Time Sampled	6/4/97 9:02	6/4/97 11:14	6/17/97 13:05	6/17/97 13:30	6/17/97 17:20	6/18/97 9:40	6/18/97 13:30	6/18/97 16:30	6/18/97 18:35	6/18/97 20:30	6/19/97 8:05	6/19/97 14:20	6/19/97 18:30	6/19/97 22:55	6/20/97 9:55	6/20/97 12:00	6/20/97 13:45
Carbazole	47.3	30.3	4.2	5.6	5.7	7.0	20.7	24.5	25.3	NA	7.8	NA	NA	NA	NA	NA	10.1
Naphthalene	34.9	17.4	12.0	15.8	12.5	9.8	61.7	30.9	32.7	NA	10.2	NA	NA	NA	NA	NA	10.4
2-Methylnaphthalene	13.8	ND	2.3	5.8	2.3	2.1	6.1	3.8	5.4	NA	3.9	NA	NA	NA	NA	NA	12.8
Acenaphthylene	2.5	ND	ND	0.3	0.3	0.4	1.0	1.5	1.6	NA	1.0	NA	NA	NA	NA	NA	2.5
Acenaphthene	35.4	20.4	7.7	8.9	9.2	11.0	20.1	19.6	21.6	NA	19.9	NA	NA	NA	NA	NA	60.6
Dibenzofuran	34.1	21.6	6.4	7.3	7.6	10.0	17.2	17.5	20.2	NA	24.7	NA	NA	NA	NA	NA	92.4
Fluorene	38.5	22.0	7.7	8.6	9.2	10.2	17.1	16.9	19.0	NA	20.3	NA	NA	NA	NA	NA	75.9
Phenanthrene	404.0	335.3	103.8	119.6	122.5	88.7	173.6	114.9	119.3	NA	113.4	NA	NA	NA	NA	NA	425.5
Anthracene	55.1	50.9	19.4	22.5	22.8	24.7	32.1	32.3	39.4	NA	8.0	NA	NA	NA	NA	NA	77.2
Fluoranthene	103.4	69.1	29.3	35.1	36.2	41.3	50.5	52.8	58.0	NA	25.1	NA	NA	NA	NA	NA	196.9
Pyrene	78.7	53.0	18.3	21.2	21.5	27.7	31.2	35.3	38.2	NA	41.4	NA	NA	NA	NA	NA	154.8
Chrysene	ND	ND	ND	ND	0.5	0.7	0.7	0.9	1.1	NA	1.8	NA	NA	NA	NA	NA	6.9
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
Benzo[a]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	1.5
Indeno[1,2,3-cd]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
Dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
Benzo[ghi]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA	NA	ND
Pentachlorophenol	7.2	1.9	1.5	1.8	3.5	1.3	3.0	2.8	3.3	NA	1.0	NA	NA	NA	NA	NA	1.0
Total Oxygenates (µg/L)	62	17	4	4	8	8	18	23	23	—	18	—	—	—	—	—	19
Total PAH (µg/L)	852	620	211	251	250	235	434	356	387	—	279	—	—	—	—	—	1133
Total Cl-Phenols (µg/L)	7	2	2	2	3	1	3	3	3	—	1	—	—	—	—	—	1
Total GC-MS (µg/L)	921	639	216	257	261	244	455	382	414	—	298	—	—	—	—	—	1153
% Oxygenates	6.7	2.7	1.9	1.7	2.9	3.2	3.9	6.1	5.6	—	6.1	—	—	—	—	—	1.7

Table 1 (continued). Results of groundwater chemical analyses for Well MW-36

Sample Name	MW-36 (6/20 1415)	MW-36 (6/26 1330)	MW-36 (6/26 1450)	MW-36 (6/30 1340)	MW-36 (6/30 1810)
Date/Time Sampled	6/20/97 14:15	6/26/97 13:30	6/26/97 14:50	6/30/97 13:40	6/30/97 18:10
pH	NA	7.1	7.0	6.9	7.0
TIC (µg C/g)	NA	44.6	45.7	48.4	47.1
Cations (µg/g)					
Al	ND	ND	ND	ND	ND
B	ND	ND	ND	ND	ND
Ca	73.18	66.72	68.02	68.85	75.19
Cr	ND	ND	ND	ND	ND
Cu	ND	0.02	ND	ND	ND
Fe	0.23	0.32	0.24	0.21	0.36
K	2.11	2.40	2.80	2.61	2.54
Mg	12.29	10.95	11.07	11.52	12.28
Mn	ND	ND	ND	ND	ND
Na	18.72	19.23	19.66	19.45	18.24
S	1.74	1.70	1.77	1.76	1.84
Si	16.88	21.87	22.75	21.40	19.95
Sr	0.04	0.03	0.03	0.03	0.04
Zn	ND	ND	ND	ND	ND
Anions (µg/g)					
Fluoride	NA	ND	ND	ND	ND
Chloride	NA	19.5	18.8	20.3	20.7
Nitrite	NA	ND	ND	ND	ND
Bromide	NA	ND	ND	ND	ND
Nitrate	NA	35.6	35.4	36.5	37.7
Phosphate	NA	ND	ND	ND	ND
Sulfate	NA	34.1	34.1	36.8 †	36.8
Semivolatile Organics (µg/L)					
Phenol	NA	0.6	0.5	0.3	0.2
2-Methylphenol	NA	0.3	0.2	0.2	0.1
3- and 4-Methylphenol	NA	1.2	0.9	0.7	0.4
2,4-Dimethylphenol	NA	1.8	0.1	ND	0.0
Benzoic acid	NA	8.4	0.0	5.2	4.0
Fluorenone	NA	27.4	24.8	19.4	17.7
Anthrone	NA	3.3	3.5	4.1	2.2

Sample Name	MW-36 (6/20 1415)	MW-36 (6/26 1330)	MW-36 (6/26 1450)	MW-36 (6/30 1340)	MW-36 (6/30 1810)
Date/Time Sampled	6/20/97 14:15	6/26/97 13:30	6/26/97 14:50	6/30/97 13:40	6/30/97 18:10
9,10-Anthracenedione	NA	14.3	14.1	25.5	26.7
7,8-Benzoquinoline	NA	9.3	7.9	5.6	2.7
Carbazole	NA	15.2	11.7	6.7	8.6
Naphthalene	NA	3.1	5.0	6.4	7.3
2-Methylnaphthalene	NA	9.3	11.6	5.1	4.0
Acenaphthylene	NA	3.4	4.1	2.1	2.3
Acenaphthene	NA	71.2	91.2	29.3	34.8
Dibenzofuran	NA	105.7	132.4	49.4	58.2
Fluorene	NA	89.2	105.2	57.5	51.0
Phenanthrene	NA	836.1	873.2	763.2	500.4
Anthracene	NA	178.2	169.6	166.3	85.8
Fluoranthene	NA	379.3	442.1	610.3	292.2
Pyrene	NA	344.0	377.0	408.1	235.2
Chrysene	NA	22.0	23.7	17.2	6.2
Benzo[b]fluoranthene	NA	1.7	1.6	1.4	ND
Benzo[k]fluoranthene	NA	1.3	1.2	1.0	ND
Benzo[a]pyrene	NA	1.8	1.9	1.6	ND
Indeno[1,2,3-cd]pyrene	NA	ND	ND	ND	ND
Dibenz[ah]anthracene	NA	ND	ND	ND	ND
Benzo[ghi]perylene	NA	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	NA	0.9	0.4	0.1	0.3
2,3,4,5-Tetrachlorophenol	NA	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	NA	0.2	0.1	0.1	0.1
Pentachlorophenol	NA	2.5	1.3	1.8	2.0
Total Oxygenates (µg/L)	–	57	44	55	51
Total PAH (µg/L)	–	2071	2259	2131	1289
Total Cl-Phenols (µg/L)	–	4	2	2	2
Total GC-MS (µg/L)	–	2132	2305	2189	1342
% Oxygenates	–	2.7	1.9	2.5	3.8

Table 2. Results of groundwater chemical analyses for Well S-13

Sample Name	S-13 (5/23 0830)	S-13 (5/23 1350)	S-13 (5/28 1255)	S-13 (6/4 1605)	S-13 (6/16 1700)	S-13 (6/17 1140)	S-13 (6/18 2320)	S-13 (6/19 0740)	S-13 (6/19 1025)	S-13 (6/19 1340)	S-13 (6/19 1750)	S-13 (6/19 2225)	S-13 (6/20 0830)	S-13 (6/20 1145)	S-13 (6/20 1330)	S-13 (6/26 1245)	S-13 (6/30 1445)
Date/Time Sampled	5/23/97 8:30	5/23/97 13:50	5/28/97 12:55	6/4/97 16:05	6/16/97 17:00	6/17/97 11:40	6/18/97 23:20	6/19/97 7:40	6/19/97 10:25	6/19/97 13:40	6/19/97 17:50	6/19/97 22:25	6/20/97 8:30	6/20/97 11:45	6/20/97 13:30	6/26/97 12:45	6/30/97 14:45
pH	7.0	7.0	7.0	NA	7.1	7.0	6.7	6.6	6.6	7.0	7.0	6.8	6.8	7.0	7.0	7.0	7.0
TIC (µg C/g)	52.0	52.0	47.1	NA	47.6	49.1	50.4	51.5	51.4	50.7	50.4	48.8	48.7	48.2	47.4	41.0	44.2
Cations (µg/g)																	
Al	NA	0.07	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	0.07	0.06
B	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	ND
Ca	NA	80.80	76.68	NA	NA	NA	NA	NA	NA	74.12	NA	NA	NA	NA	NA	66.27	71.20
Cr	NA	ND	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	0.03
Cu	NA	0.05	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	0.25	0.43
Fe	NA	1.53	0.09	NA	NA	NA	NA	NA	NA	0.03	NA	NA	NA	NA	NA	0.42	0.68
K	NA	1.80	3.31	NA	NA	NA	NA	NA	NA	2.60	NA	NA	NA	NA	NA	2.82	3.02
Mg	NA	14.40	12.59	NA	NA	NA	NA	NA	NA	12.21	NA	NA	NA	NA	NA	11.06	11.59
Mn	NA	0.03	ND	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	ND
Na	NA	18.60	24.23	NA	NA	NA	NA	NA	NA	22.23	NA	NA	NA	NA	NA	17.52	17.67
S	NA	11.40	2.80	NA	NA	NA	NA	NA	NA	1.91	NA	NA	NA	NA	NA	1.71	1.73
Si	NA	14.90	29.12	NA	NA	NA	NA	NA	NA	22.65	NA	NA	NA	NA	NA	25.68	22.76
Sr	NA	0.56	0.04	NA	NA	NA	NA	NA	NA	0.03	NA	NA	NA	NA	NA	0.03	0.03
Zn	NA	0.08	ND	NA	NA	NA	NA	NA	NA	0.03	NA	NA	NA	NA	NA	0.09	0.18
Anions (µg/g)																	
Fluoride	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA
Chloride	NA	19.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	19.6	NA
Nitrite	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA
Bromide	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA
Nitrate	NA	34.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34.5	NA
Phosphate	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA
Sulfate	NA	40.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	32.0	NA
Semivolatile Organics (µg/L)																	
Phenol	2.0	0.5	4.0	ND	ND	ND	NA	0.8	NA	NA	NA	1.3	NA	NA	2.1	ND	ND
2-Methylphenol	0.6	ND	0.8	ND	ND	ND	NA	1.6	NA	NA	NA	4.1	NA	NA	3.2	0.2	ND
3- and 4-Methylphenol	1.6	ND	3.0	ND	ND	ND	NA	2.0	NA	NA	NA	4.2	NA	NA	3.8	1.0	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	NA	1.4	NA	NA	NA	1.6	NA	NA	2.0	ND	ND
Benzoic acid	ND	ND	16.6	ND	ND	ND	NA	6.8	NA	NA	NA	11.4	NA	NA	9.4	ND	ND
Fluorenone	36.8	3.9	55.1	34.1	14.9	12.9	NA	16.7	NA	NA	NA	38.5	NA	NA	55.8	50.5	32.1
Anthrone	3.5	ND	9.6	6.9	3.2	2.9	NA	3.4	NA	NA	NA	8.1	NA	NA	9.7	7.4	7.2
9,10-Anthracenedione	3.2	18.0	21.5	6.9	3.1	4.4	NA	21.9	NA	NA	NA	19.6	NA	NA	22.8	45.4	36.1
7,8-Benzoquinoline	6.1	ND	9.3	4.1	ND	ND	NA	1.9	NA	NA	NA	8.5	NA	NA	7.8	8.2	4.6

Sample Name	S-13 (5/23 0830)	S-13 (5/23 1350)	S-13 (5/28 1255)	S-13 (6/4 1605)	S-13 (6/16 1700)	S-13 (6/17 1140)	S-13 (6/18 2320)	S-13 (6/19 0740)	S-13 (6/19 1025)	S-13 (6/19 1340)	S-13 (6/19 1750)	S-13 (6/19 2225)	S-13 (6/20 0830)	S-13 (6/20 1145)	S-13 (6/20 1330)	S-13 (6/26 1245)	S-13 (6/30 1445)
Date/Time Sampled	5/23/97 8:30	5/23/97 13:50	5/28/97 12:55	6/4/97 16:05	6/16/97 17:00	6/17/97 11:40	6/18/97 23:20	6/19/97 7:40	6/19/97 10:25	6/19/97 13:40	6/19/97 17:50	6/19/97 22:25	6/20/97 8:30	6/20/97 11:45	6/20/97 13:30	6/26/97 12:45	6/30/97 14:45
Carbazole	14.7	ND	80.6	32.9	6.9	5.4	NA	15.7	NA	NA	NA	39.6	NA	NA	59.4	25.5	26.6
Naphthalene	36.9	7.7	14.6	28.4	6.0	9.1	NA	18.2	NA	NA	NA	44.3	NA	NA	33.6	12.4	12.1
2-Methylnaphthalene	65.0	6.6	25.4	12.0	3.9	3.7	NA	4.8	NA	NA	NA	22.7	NA	NA	16.3	5.9	14.0
Acenaphthylene	18.8	1.8	6.3	3.2	ND	0.8	NA	3.6	NA	NA	NA	7.2	NA	NA	10.0	4.8	2.3
Acenaphthene	308.2	30.3	71.2	35.1	28.1	25.6	NA	29.1	NA	NA	NA	86.9	NA	NA	102.6	50.1	39.7
Dibenzofuran	490.3	76.9	264.5	81.5	41.4	46.9	NA	37.0	NA	NA	NA	96.4	NA	NA	117.3	99.2	75.0
Fluorene	457.4	65.2	199.8	49.4	29.6	30.6	NA	34.0	NA	NA	NA	124.3	NA	NA	111.0	113.7	57.2
Phenanthrene	1446.4	376.6	878.7	721.0	210.9	359.7	NA	353.2	NA	NA	NA	1910.0	NA	NA	1898.1	2142.5	1532.9
Anthracene	669.0	16.9	200.5	121.6	67.0	70.5	NA	51.7	NA	NA	NA	635.4	NA	NA	488.1	827.4	505.6
Fluoranthene	437.2	47.3	228.9	150.5	112.8	107.8	NA	139.5	NA	NA	NA	672.2	NA	NA	763.3	1284.6	788.4
Pyrene	308.6	30.5	187.1	117.3	77.7	73.1	NA	100.5	NA	NA	NA	478.9	NA	NA	570.0	1017.7	630.3
Chrysene	ND	ND	ND	ND	4.6	1.5	NA	3.6	NA	NA	NA	13.9	NA	NA	10.8	43.5	28.1
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	ND	NA	NA	1.3	1.5	2.1
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	ND	NA	NA	0.8	1.1	1.7
Benzo[a]pyrene	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	1.5	NA	NA	1.6	1.8	2.2
Indeno[1,2,3-cd]pyrene	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	ND	NA	NA	ND	ND	ND
Dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	ND	NA	NA	ND	ND	ND
Benzo[ghi]perylene	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	ND	NA	NA	0.1	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	NA	0.1	NA	NA	NA	0.2	NA	NA	0.4	1.6	5.2
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	NA	ND	NA	NA	NA	ND	NA	NA	0.1	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	NA	0.1	NA	NA	NA	0.1	NA	NA	0.3	0.3	ND
Pentachlorophenol	0.7	ND	6.1	2.3	13.7	0.8	NA	2.1	NA	NA	NA	2.5	NA	NA	4.3	1.1	4.2
Total Oxygenates (µg/L)	48	22	110	48	21	20	-	55	-	-	-	89	-	-	109	105	75
Total PAH (µg/L)	4258	660	2167	1357	589	735	-	793	-	-	-	4142	-	-	4192	5640	3723
Total Cl-Phenols (µg/L)	1	0	6	2	14	1	-	2	-	-	-	3	-	-	5	3	9
Total GC-MS (µg/L)	4307	682	2283	1407	624	756	-	850	-	-	-	4233	-	-	4306	5747	3808
% Oxygenates	1.1	3.3	4.8	3.4	3.4	2.7	-	6.4	-	-	-	2.1	-	-	2.5	1.8	2.0

Table 2 (continued). Results of groundwater chemical analyses for Well S-13

Sample Name	S-13 (7/16 1155)	S-13 (7/16 1650)	S-13 (10/23 1030)	S-13 (12/16 1445)
Date/Time Sampled	7/16/97 11:55	7/16/97 16:50	10/23/97 10:30	12/16/97 14:45
pH	6.8	6.8	8.5	7.1
TIC (µg C/g)	43.9	46.6	41.3	47.0
Cations (µg/g)				
Al	NA	NA	NA	NA
B	NA	NA	NA	NA
Ca	NA	NA	NA	NA
Cr	NA	NA	NA	NA
Cu	NA	NA	NA	NA
Fe	NA	NA	NA	NA
K	NA	NA	NA	NA
Mg	NA	NA	NA	NA
Mn	NA	NA	NA	NA
Na	NA	NA	NA	NA
S	NA	NA	NA	NA
Si	NA	NA	NA	NA
Sr	NA	NA	NA	NA
Zn	NA	NA	NA	NA
Anions (µg/g)				
Fluoride	ND	ND	NA	NA
Chloride	20.4	19.2	NA	16.8
Nitrite	ND	ND	NA	NA
Bromide	ND	ND	NA	NA
Nitrate	37.2	36.4	NA	25.4
Phosphate	ND	ND	NA	NA
Sulfate	54.1	47.6	NA	31.3 ¹
Semivolatile Organics (µg/L)				
Phenol	0.7	ND	ND	0.7
2-Methylphenol	0.9	ND	ND	0.1
3- and 4-Methylphenol	1.9	ND	ND	0.7
2,4-Dimethylphenol	ND	ND	ND	ND
Benzoic acid	4.7	ND	ND	12.4
Fluorenone	16.1	5.9	ND	20.7
Anthrone	1.2	ND	ND	0.8

Sample Name	S-13 (7/16 1155)	S-13 (7/16 1650)	S-13 (10/23 1030)	S-13 (12/16 1445)
Date/Time Sampled	7/16/97 11:55	7/16/97 16:50	10/23/97 10:30	12/16/97 14:45
9,10-Anthracenedione	36.6	6.2	ND	8.3
7,8-Benzoquinoline	1.3	ND	ND	ND
Carbazole	31.4	7.2	ND	ND
Naphthalene	13.1	7.8	2.3	22.7
2-Methylnaphthalene	14.1	7.0	3.1	8.7
Acenaphthylene	1.1	ND	0.4	0.8
Acenaphthene	15.5	4.4	6.0	5.3
Dibenzofuran	41.4	15.2	11.3	8.2
Fluorene	38.8	16.0	15.3	3.2
Phenanthrene	405.1	178.6	790.7	46.3
Anthracene	16.7	53.2	47.1	1.2
Fluoranthene	162.2	50.0	227.1	59.9
Pyrene	149.7	44.4	292.1	45.7
Chrysene	8.0	4.2	30.1	9.4
Benzo[b]fluoranthene	ND	1.2	1.5	2.3
Benzo[k]fluoranthene	ND	0.8	3.5	2.5
Benzo[a]pyrene	1.4	1.4	0.6	0.7
Indeno[1,2,3-cd]pyrene	ND	ND	ND	ND
Dibenz[ah]anthracene	ND	ND	ND	ND
Benzo[ghi]perylene	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	2.4	ND	ND	18.2
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	2.7
Pentachlorophenol	5.5	ND	13.9	77.9
Total Oxygenates (µg/L)	62	12	0	44
Total PAH (µg/L)	900	391	1431	217
Total Cl-Phenols (µg/L)	8	0	14	99
Total GC-MS (µg/L)	970	404	1445	359
% Oxygenates	6.4	3.0	0.0	12.2

Table 3. Results of groundwater chemical analyses for Well S-12

Sample Name	S-12 (5/20 1515)	S-12 (5/22 0845)	S-12 (5/28 1440)	S-12 (6/17 1125)	S-12 (6/30 1525)	S-12 (7/16 1255)
Date/Time Sampled	5/20/97 15:15	5/22/97 8:45	5/28/97 14:40	6/17/97 11:25	6/30/97 15:25	7/16/97 12:55
pH	7.0	NA	7.0	7.0	6.8	7.0
TIC (µg C/g)	NA	NA	49.1	49.6	40.1	30.1
Cations (µg/g)						
Al	NA	NA	NA	NA	ND	NA
B	NA	NA	NA	NA	ND	NA
Ca	NA	NA	NA	NA	84.39	NA
Cr	NA	NA	NA	NA	ND	NA
Cu	NA	NA	NA	NA	0.07	NA
Fe	NA	NA	NA	NA	ND	NA
K	NA	NA	NA	NA	5.50	NA
Mg	NA	NA	NA	NA	12.35	NA
Mn	NA	NA	NA	NA	ND	NA
Na	NA	NA	NA	NA	45.29	NA
S	NA	NA	NA	NA	5.64	NA
Si	NA	NA	NA	NA	31.94	NA
Sr	NA	NA	NA	NA	0.05	NA
Zn	NA	NA	NA	NA	0.12	NA
Anions (µg/g)						
Fluoride	NA	NA	NA	NA	ND	ND
Chloride	NA	NA	NA	NA	37.8	26.9
Nitrite	NA	NA	NA	NA	ND	ND
Bromide	NA	NA	NA	NA	ND	ND
Nitrate	NA	NA	NA	NA	32.9	32.0
Phosphate	NA	NA	NA	NA	ND	ND
Sulfate	NA	NA	NA	NA	110.0	87.0
Semivolatile Organics (µg/L)						
Phenol	7.5	4.9	8.1	0.8	ND	4.8
2-Methylphenol	1.7	1.5	1.4	ND	ND	3.8
3- and 4-Methylphenol	7.5	5.4	4.2	ND	ND	9.2
2,4-Dimethylphenol	10.7	7.3	ND	ND	ND	14.8
Benzoic acid	ND	ND	17.3	ND	ND	53.2
Fluorenone	212.1	164.3	110.1	19.1	63.6	99.6
Anthrone	17.4	22.0	13.2	4.2	ND	9.6
9,10-Anthracenedione	26.0	27.9	20.9	6.5	ND	20.5
7,8-Benzoquinoline	52.6	97.1	54.7	6.6	ND	25.4

Carbazole	564.8	465.0	306.3	27.3	210.3	80.4
Naphthalene	142.1	125.8	86.1	17.7	174.8	40.8
2-Methylnaphthalene	223.1	89.4	55.2	34.5	111.2	43.3
Acenaphthylene	61.6	25.4	8.9	1.9	9.8	6.1
Acenaphthene	378.8	195.4	156.9	77.4	272.6	116.5
Dibenzofuran	686.5	469.5	341.3	90.6	591.7	194.4
Fluorene	245.1	146.8	56.8	39.6	163.8	87.4
Phenanthrene	692.4	906.3	857.7	356.3	2036.7	882.1
Anthracene	113.5	246.0	159.0	85.8	473.1	192.9
Fluoranthene	27.7	243.2	275.4	121.1	497.6	433.1
Pyrene	14.8	161.5	209.0	78.1	287.3	400.6
Chrysene	ND	ND	ND	ND	ND	88.4
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	6.0
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	4.4
Benzo[a]pyrene	ND	ND	ND	ND	ND	7.1
Indeno[1,2,3-cd]pyrene	ND	ND	ND	ND	ND	ND
Dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND
Benzo[ghi]perylene	ND	ND	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	10.9
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND
Pentachlorophenol	16.0	11.4	7.0	0.5	ND	18.0
Total Oxygenates (µg/L)	283	233	175	31	64	215
Total PAH (µg/L)	3203	3171	2567	937	4829	2609
Total Cl-Phenols (µg/L)	16	11	7	1	0	29
Total GC-MS (µg/L)	3502	3416	2749	968	4892	2853
% Oxygenates	8.1	6.8	6.4	3.2	1.3	7.6

Table 4. Results of groundwater chemical analyses for Well S-14

Sample Name	S-14 (5/6 1620)	S-14 (5/22 1150)	S-14 (5/28 1330)	S-14 (6/4 1605)	S-14 (6/17 1115)	S-14 (6/30 1318)	S-14 (7/16 1600)	S-14 (12/16 1254)	S-14 (12/16 1254)
Date/Time Sampled	5/6/97 16:20	5/22/97 11:50	5/28/97 13:30	6/4/97 16:05	6/17/97 11:15	6/30/97 13:18	7/16/97 16:00	12/16/97 12:54	12/16/97 12:54
pH	6.9	7.0	7.1	NA	6.8	7.0	6.8	7.0	NA
TIC (µg C/g)	51.5	51.0	54.4	NA	58.9	60.4	57.8	40.0	NA
Cations (µg/g)									
Al	ND	ND	ND	NA	NA	ND	NA	NA	NA
B	ND	ND	ND	NA	NA	ND	NA	NA	NA
Ca	62.48	76.92	76.17	NA	NA	76.69	NA	NA	NA
Cr	ND	ND	ND	NA	NA	0.03	NA	NA	NA
Cu	ND	ND	0.02	NA	NA	ND	NA	NA	NA
Fe	0.18	0.04	0.04	NA	NA	0.14	NA	NA	NA
K	1.99	1.64	1.53	NA	NA	2.79	NA	NA	NA
Mg	10.79	13.24	13.22	NA	NA	12.72	NA	NA	NA
Mn	0.07	0.07	0.07	NA	NA	0.03	NA	NA	NA
Na	15.97	16.41	16.81	NA	NA	24.24	NA	NA	NA
S	1.12	1.65	1.59	NA	NA	2.08	NA	NA	NA
Si	15.07	13.94	14.13	NA	NA	24.45	NA	NA	NA
Sr	0.03	0.04	0.04	NA	NA	0.04	NA	NA	NA
Zn	0.12	0.05	0.13	NA	NA	0.77	NA	NA	NA
Anions (µg/g)									
Fluoride	ND	ND	NA	NA	NA	ND	ND	ND	NA
Chloride	12.8	16.9	NA	NA	NA	19.8	20.5	16.8	NA
Nitrite	ND	ND	NA	NA	NA	ND	ND	ND	NA
Bromide	ND	ND	NA	NA	NA	ND	ND	ND	NA
Nitrate	ND	14.7	NA	NA	NA	ND	7.3	27.1	NA
Phosphate	ND	ND	NA	NA	NA	ND	ND	ND	NA
Sulfate	17.1	38.5	NA	NA	NA	32.2	49.9	79.6	NA
Semivolatile Organics (µg/L)									
Phenol	0.8	1.2	0.7	7.1	16.6	35.0	12.7	3.6	4.2
2-Methylphenol	ND	ND	ND	2.8	5.1	ND	4.9	0.8	0.8
3- and 4-Methylphenol	ND	ND	ND	10.3	20.6	ND	13.3	3.2	3.6
2,4-Dimethylphenol	ND	ND	ND	23.8	29.3	ND	16.2	0.5	0.6
Benzoic acid	ND	ND	ND	ND	ND	ND	ND	14.6	20.3
Fluorenone	7.4	29.1	40.3	59.1	58.4	116.6	137.7	60.9	57.6
Anthrone	ND	ND	ND	3.9	4.9	ND	3.4	1.4	1.4
9,10-Anthracenedione	4.2	5.4	11.9	9.7	4.3	ND	82.3	13.1	12.8
7,8-Benzoquinoline	12.4	26.6	33.0	59.2	74.4	ND	86.5	ND	ND

Sample Name	S-14 (5/6 1620)	S-14 (5/22 1150)	S-14 (5/28 1330)	S-14 (6/4 1605)	S-14 (6/17 1115)	S-14 (6/30 1318)	S-14 (7/16 1600)	S-14 (12/16 1254)	S-14 (12/16 1254)
Date/Time Sampled	5/6/97 16:20	5/22/97 11:50	5/28/97 13:30	6/4/97 16:05	6/17/97 11:15	6/30/97 13:18	7/16/97 16:00	12/16/97 12:54	12/16/97 12:54
Carbazole	112.7	172.5	188.9	768.8	753.3	374.4	235.6	ND	ND
Naphthalene	382.2	839.4	1082.6	1849.1	4585.4	11391.2	1768.0	248.5	226.2
2-Methylnaphthalene	250.3	872.8	1226.3	1620.6	2819.2	19318.7	1694.3	126.3	118.7
Acenaphthylene	6.3	9.7	9.0	11.1	6.2	71.2	16.6	3.6	3.1
Acenaphthene	391.6	750.8	1114.0	696.6	712.2	11515.5	1391.2	52.8	48.5
Dibenzofuran	303.5	517.4	731.8	477.0	482.1	8799.2	1086.2	45.1	40.4
Fluorene	162.5	473.3	712.3	318.5	291.7	6641.2	771.5	15.8	13.8
Phenanthrene	307.3	982.2	1362.9	614.8	592.6	6818.7	1595.2	27.6	23.5
Anthracene	39.7	174.5	267.4	105.4	98.6	1329.0	122.4	3.2	3.0
Fluoranthene	55.8	422.5	726.7	127.3	117.2	559.6	495.6	3.7	2.7
Pyrene	44.4	408.0	719.8	112.7	87.4	344.6	391.8	3.5	2.3
Chrysene	5.3	84.8	164.6	21.5	16.6	ND	83.0	ND	0.5
Benzo[b]fluoranthene	ND	17.8	38.5	4.6	4.4	ND	35.6	ND	0.1
Benzo[k]fluoranthene	ND	23.2	44.3	5.3	4.6	ND	27.8	ND	0.1
Benzo[a]pyrene	ND	19.9	42.5	4.8	4.9	ND	32.9	ND	0.2
Indeno[1,2,3-cd]pyrene	ND	ND	10.7	ND	ND	ND	23.7	ND	ND
Dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[ghi]perylene	ND	ND	7.0	ND	ND	ND	17.5	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	19.5	46.4	ND	12.0	7.4	7.5
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	0.5	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	8.8	11.6	ND	9.9	2.1	1.9
Pentachlorophenol	1.1	23.5	11.2	201.4	300.4	84.2	72.3	33.3	31.2
Total Oxygenates (µg/L)	12	36	53	117	139	152	270	98	101
Total PAH (µg/L)	2074	5795	8482	6797	10651	67163	9875	530	483
Total Cl-Phenols (µg/L)	1	24	11	230	359	84	94	43	41
Total GC-MS (µg/L)	2087	5854	8546	7144	11148	67399	10240	672	625
% Oxygenates	0.6	0.6	0.6	1.6	1.2	0.2	2.6	14.6	16.2

Table 5. Results of groundwater chemical analyses for Well S-15

Sample Name	S-15 (5/28 1630)	S-15 (6/19 1210)	S-15 (6/30 1615)	S-15 (7/16 1520)	S-15 (12/16 1310)	S-15 (12/16 1310)
Date/Time Sampled	5/28/97 16:30	6/19/97 12:10	6/30/97 16:15	7/16/97 15:20	12/16/97 13:10	12/16/97 13:10
pH	7.0	6.9	6.7	6.6	6.8	NA
TIC (µg C/g)	57.3	57.1	56.7	55.6	41.1	NA
Cations (µg/g)						
Al	ND	NA	ND	NA	NA	NA
B	ND	NA	ND	NA	NA	NA
Ca	75.76	NA	77.81	NA	NA	NA
Cr	0.05	NA	0.07	NA	NA	NA
Cu	0.04	NA	0.13	NA	NA	NA
Fe	0.22	NA	0.25	NA	NA	NA
K	2.11	NA	3.82	NA	NA	NA
Mg	13.58	NA	12.69	NA	NA	NA
Mn	0.08	NA	0.05	NA	NA	NA
Na	17.74	NA	30.91	NA	NA	NA
S	1.71	NA	3.18	NA	NA	NA
Si	13.21	NA	33.50	NA	NA	NA
Sr	0.04	NA	0.04	NA	NA	NA
Zn	1.30	NA	3.03	NA	NA	NA
Anions (µg/g)						
Fluoride	NA	NA	ND	ND	ND	NA
Chloride	NA	NA	30.4	17.9	14.5	NA
Nitrite	NA	NA	ND	ND	ND	NA
Bromide	NA	NA	ND	ND	ND	NA
Nitrate	NA	NA	14.5	7.6	16.2	NA
Phosphate	NA	NA	ND	ND	ND	NA
Sulfate	NA	NA	69.8	29.5	50.6	NA
Semivolatile Organics (µg/L)						
Phenol	0.7	NA	ND	14.5	0.4	3.7
2-Methylphenol	ND	NA	ND	7.4	0.1	0.4
3- and 4-Methylphenol	ND	NA	ND	22.1	0.8	1.8
2,4-Dimethylphenol	ND	NA	ND	ND	ND	ND
Benzoic acid	ND	NA	ND	84.9	7.8	16.1
Fluorenone	26.2	NA	68.8	318.0	102.6	100.8
Anthrone	ND	NA	ND	9.6	8.1	7.5

Sample Name	S-15 (5/28 1630)	S-15 (6/19 1210)	S-15 (6/30 1615)	S-15 (7/16 1520)	S-15 (12/16 1310)	S-15 (12/16 1310)
Date/Time Sampled	5/28/97 16:30	6/19/97 12:10	6/30/97 16:15	7/16/97 15:20	12/16/97 13:10	12/16/97 13:10
9,10-Anthracenedione	6.2	NA	ND	57.8	52.2	55.7
7,8-Benzoquinoline	25.0	NA	ND	72.5	ND	ND
Carbazole	150.7	NA	232.5	347.6	ND	ND
Naphthalene	457.5	NA	5471.3	3974.2	160.3	172.6
2-Methylnaphthalene	578.4	NA	907.5	1919.4	149.0	151.7
Acenaphthylene	4.2	NA	ND	36.4	16.8	25.3
Acenaphthene	621.9	NA	543.8	865.5	359.1	343.6
Dibenzofuran	385.2	NA	627.5	937.4	409.6	403.0
Fluorene	358.3	NA	151.3	464.5	137.2	133.9
Phenanthrene	745.4	NA	1078.8	1426.8	975.7	912.9
Anthracene	136.8	NA	206.3	275.4	15.0	16.6
Fluoranthene	337.0	NA	145.0	424.4	366.6	379.2
Pyrene	310.4	NA	111.3	348.0	293.0	286.8
Chrysene	69.5	NA	ND	30.0	41.2	40.2
Benzo[b]fluoranthene	14.2	NA	ND	11.9	3.9	4.0
Benzo[k]fluoranthene	18.1	NA	ND	9.0	4.6	4.1
Benzo[a]pyrene	16.7	NA	ND	5.7	2.8	2.4
Indeno[1,2,3-cd]pyrene	ND	NA	ND	ND	ND	ND
Dibenz[ah]anthracene	ND	NA	ND	ND	ND	ND
Benzo[ghi]perylene	ND	NA	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	NA	48.8	141.9	75.0	65.7
2,3,4,5-Tetrachlorophenol	ND	NA	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	NA	92.5	160.4	11.9	10.8
Pentachlorophenol	18.3	NA	2111.3	3388.4	576.8	575.7
Total Oxygenates (µg/L)	33	—	69	514	172	186
Total PAH (µg/L)	4229	—	9475	11149	2935	2876
Total Cl-Phenols (µg/L)	18	—	2253	3691	664	652
Total GC-MS (µg/L)	4281	—	11796	15354	3771	3715
% Oxygenates	0.8	—	0.6	3.3	4.6	5.0

Table 6. Results of groundwater chemical analyses for Wells MW-41, MW-44, EW-1, EW-2, EW-3 and EW-5

Sample Name	MW-41 (5/6 1540)	MW-41 (6/18 1100)	MW-41 (7/16 1820)	MW-44 (7/17 0910)	EW-1 (5/8 1000)	EW-1 (6/16 1630)	EW-2 (6/19 1240)	EW-3 (5/6 1515)	EW-3 (6/16 1530)	EW-5 (7/17 1020)
Date/Time Sampled	5/6/97 15:40	6/18/97 11:00	7/16/97 18:20	7/17/97 9:10	5/8/97 10:00	6/16/97 16:30	6/19/97 12:40	5/6/97 15:15	6/16/97 15:30	7/17/97 10:20
pH	6.9	7.1	6.5	6.9	6.9	7.0	7.0	6.9	7.0	7.3
TIC (µg C/g)	44.7	45.9	72.8	66.7	56.8	50.5	66.0	47.8	43.9	35.5
Cations (µg/g)										
Al	ND	NA	NA	NA	ND	NA	NA	ND	NA	NA
B	ND	NA	NA	NA	ND	NA	NA	ND	NA	NA
Ca	57.87	NA	NA	NA	79.90	NA	NA	62.61	NA	NA
Cr	ND	NA	NA	NA	ND	NA	NA	ND	NA	NA
Cu	ND	NA	NA	NA	0.02	NA	NA	0.02	NA	NA
Fe	ND	NA	NA	NA	0.61	NA	NA	0.02	NA	NA
K	1.11	NA	NA	NA	1.80	NA	NA	2.04	NA	NA
Mg	10.80	NA	NA	NA	14.60	NA	NA	10.91	NA	NA
Mn	ND	NA	NA	NA	0.21	NA	NA	0.03	NA	NA
Na	17.17	NA	NA	NA	19.10	NA	NA	17.30	NA	NA
S	1.23	NA	NA	NA	11.40	NA	NA	1.32	NA	NA
Si	17.20	NA	NA	NA	14.00	NA	NA	15.17	NA	NA
Sr	0.02	NA	NA	NA	0.59	NA	NA	0.03	NA	NA
Zn	ND	NA	NA	NA	0.08	NA	NA	0.03	NA	NA
Anions (µg/g)										
Fluoride	ND	NA	ND	ND	ND	NA	NA	ND	NA	ND
Chloride	10.5	NA	19.7	22.2	17.4	NA	NA	11.1	NA	7.9
Nitrite	ND	NA	ND	ND	ND	NA	NA	ND	NA	ND
Bromide	ND	NA	ND	ND	ND	NA	NA	ND	NA	ND
Nitrate	22.8	NA	23.8	35.5	32.5	NA	NA	13.6	NA	17.2
Phosphate	ND	NA	ND	ND	ND	NA	NA	ND	NA	ND
Sulfate	21.2	NA	45.4	38.8	34.4	NA	NA	21.0	NA	13.9
Semivolatile Organics (µg/L)										
Phenol	ND	1.6	1.0	ND	ND	ND	1.0	ND	ND	ND
2-Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3- and 4-Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic acid	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorenone	ND	3.7	3.4	ND	1.7	9.4	57.6	2.1	30.4	1.8
Anthrone	ND	ND	ND	ND	ND	ND	2.6	ND	ND	ND
9,10-Anthracenedione	ND	ND	1.1	ND	ND	ND	6.6	ND	4.0	ND
7,8-Benzoquinoline	ND	ND	ND	ND	ND	ND	3.3	ND	ND	ND

Carbazole	ND	ND	ND	ND	6.1	28.9	42.4	20.2	29.1	0.9
Naphthalene	ND	1.8	1.2	ND	ND	0.7	203.4	ND	12.5	ND
2-Methylnaphthalene	ND	2.1	2.5	0.5	22.2	2.9	287.8	6.4	23.7	ND
Acenaphthylene	ND	ND	ND	ND	2.3	0.0	6.9	3.4	1.2	ND
Acenaphthene	ND	ND	1.0	0.1	36.2	33.4	96.8	42.0	35.0	7.1
Dibenzofuran	ND	1.6	1.6	0.4	37.1	12.1	222.8	36.5	39.2	5.9
Fluorene	ND	0.1	0.9	ND	7.7	1.8	27.7	15.3	19.9	1.2
Phenanthrene	ND	6.8	2.5	1.7	7.0	5.9	183.2	35.7	106.2	0.5
Anthracene	ND	0.6	0.8	1.0	3.7	2.9	17.3	5.6	16.0	1.1
Fluoranthene	ND	1.4	1.0	1.1	7.2	17.7	23.9	6.6	28.4	3.1
Pyrene	ND	1.1	0.2	0.2	5.1	11.8	13.3	5.1	17.0	1.6
Chrysene	ND	ND	ND	ND	ND	0.5	ND	ND	1.3	ND
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	0.2	ND	ND	ND	ND
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND
Benzo[a]pyrene	ND	ND	ND	ND	ND	0.3	ND	ND	0.3	ND
Indeno[1,2,3-cd]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[ghi]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	1.9	ND	ND	ND	2.0	ND	0.9	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	2.0	ND	ND	ND	3.4	ND	0.8	ND
Pentachlorophenol	ND	2.0	19.3	ND	ND	11.4	134.0	ND	21.0	4.5
Total Oxygenates (µg/L)	0.0	5.4	5.5	0.0	1.7	9.4	67.7	2.1	34.4	1.8
Total PAH (µg/L)	0.0	14.0	10.1	4.6	91.5	78.3	860.1	120.2	261.5	14.6
Total Cl-Phenols (µg/L)	0.0	2.0	23.2	0.0	0.0	11.4	139.4	0.0	22.6	4.5
Total GC-MS (µg/L)	0.0	23.0	40.4	5.0	136.3	140.1	1335.5	179.0	386.9	27.7
% Oxygenates	0.0	23.3	13.6	0.0	1.2	6.7	5.1	1.2	8.9	6.4

Table 7. Results of groundwater chemical analyses for Well S-4

Sample Name	S-4 (5/23 1330)	S-4 (6/20 1100)	S-4 (6/20 1300)
Date/Time Sampled	5/23/97 13:30	6/20/97 11:00	6/20/97 13:00
pH	NA	4.6	NA
TIC (µg C/g)	NA	75.9	NA
Cations (µg/g)			
Al	NA	NA	NA
B	NA	NA	NA
Ca	NA	NA	NA
Cr	NA	NA	NA
Cu	NA	NA	NA
Fe	NA	NA	NA
K	NA	NA	NA
Mg	NA	NA	NA
Mn	NA	NA	NA
Na	NA	NA	NA
S	NA	NA	NA
Si	NA	NA	NA
Sr	NA	NA	NA
Zn	NA	NA	NA
Anions (µg/g)			
Fluoride	NA	NA	NA
Chloride	NA	NA	NA
Nitrite	NA	NA	NA
Bromide	NA	NA	NA
Nitrate	NA	NA	NA
Phosphate	NA	NA	NA
Sulfate	NA	NA	NA
Semivolatile Organics (µg/L)			
Phenol	2.4	NA	1.5
2-Methylphenol	ND	NA	ND
3- and 4-Methylphenol	ND	NA	ND
2,4-Dimethylphenol	ND	NA	ND
Benzoic acid	ND	NA	ND
Fluorenone	ND	NA	ND
Anthrone	ND	NA	ND

Sample Name	S-4 (5/23 1330)	S-4 (6/20 1100)	S-4 (6/20 1300)
Date/Time Sampled	5/23/97 13:30	6/20/97 11:00	6/20/97 13:00
9,10-Anthracenedione	ND	NA	ND
7,8-Benzoquinoline	ND	NA	ND
Carbazole	ND	NA	ND
Naphthalene	ND	NA	6.9
2-Methylnaphthalene	ND	NA	1.4
Acenaphthylene	ND	NA	0.6
Acenaphthene	ND	NA	ND
Dibenzofuran	ND	NA	ND
Fluorene	ND	NA	3.0
Phenanthrene	10.5	NA	88.6
Anthracene	1.4	NA	9.9
Fluoranthene	ND	NA	11.1
Pyrene	ND	NA	22.5
Chrysene	ND	NA	1.3
Benzo[b]fluoranthene	ND	NA	0.7
Benzo[k]fluoranthene	ND	NA	0.7
Benzo[a]pyrene	ND	NA	0.7
Indeno[1,2,3-cd]pyrene	ND	NA	ND
Dibenz[ah]anthracene	ND	NA	ND
Benzo[ghi]perylene	ND	NA	ND
2,3,5,6-Tetrachlorophenol	ND	NA	ND
2,3,4,5-Tetrachlorophenol	ND	NA	ND
2,3,4,6-Tetrachlorophenol	ND	NA	ND
Pentachlorophenol	ND	NA	ND
Total Oxygenates (µg/L)	2	—	1
Total PAH (µg/L)	12	—	148
Total Cl-Phenols (µg/L)	0	—	0
Total GC-MS (µg/L)	14	—	149
% Oxygenates	17.0	—	1.0

Table 8. Results of chemical analyses for miscellaneous water samples

Sample Name	S-13 Cond. (6/20)	S-13 Vapor (6/30)	S-13 Vapor (6/30)	S-13 Vapor (6/30)	Steam Water (6/30)	Treat. Fac. (6/30)	Top of Sep. (6/30)
Date/Time Sampled	6/20/97 13:15	6/30/97 13:15	6/30/97 13:15	6/30/97 14:20	6/30/97 17:45	6/30/97 17:15	6/30/97
pH	NA	NA	4.4	4.4	7.0	7.0	NA
TIC (µg C/g)	NA	NA	135.2	140.1	42.6	44.2	NA
Cations (µg/g)							
Al	NA	NA	NA	NA	ND	ND	NA
B	NA	NA	NA	NA	ND	ND	NA
Ca	NA	NA	NA	NA	0.07	63.80	NA
Cr	NA	NA	NA	NA	ND	ND	NA
Cu	NA	NA	NA	NA	0.02	0.03	NA
Fe	NA	NA	NA	NA	0.02	0.03	NA
K	NA	NA	NA	NA	1.78	2.98	NA
Mg	NA	NA	NA	NA	ND	9.70	NA
Mn	NA	NA	NA	NA	ND	0.02	NA
Na	NA	NA	NA	NA	126.11	31.64	NA
S	NA	NA	NA	NA	3.37	2.75	NA
Si	NA	NA	NA	NA	25.31	26.94	NA
Sr	NA	NA	NA	NA	ND	0.03	NA
Zn	NA	NA	NA	NA	0.02	0.02	NA
Anions (µg/g)							
Fluoride	NA	NA	ND	NA	ND	ND	NA
Chloride	NA	NA	5.2	NA	22.8	25.0	NA
Nitrite	NA	NA	ND	NA	ND	ND	NA
Bromide	NA	NA	ND	NA	ND	ND	NA
Nitrate	NA	NA	ND	NA	14.3	ND	NA
Phosphate	NA	NA	ND	NA	ND	ND	NA
Sulfate	NA	NA	ND	NA	79.6	57.0	NA
Semivolatile Organics (µg/L)							
Phenol	ND	ND	ND	NA	NA	18	ND
2-Methylphenol	ND	ND	ND	NA	NA	ND	ND
3- and 4-Methylphenol	ND	ND	ND	NA	NA	ND	ND
2,4-Dimethylphenol	ND	ND	ND	NA	NA	ND	ND
Benzoic acid	ND	ND	ND	NA	NA	ND	ND
Fluorenone	ND	69	125	NA	NA	183	667
Anthrone	ND	ND	ND	NA	NA	ND	ND

Sample Name	S-13 Cond. (6/20)	S-13 Vapor (6/30)	S-13 Vapor (6/30)	S-13 Vapor (6/30)	Steam Water (6/30)	Treat. Fac. (6/30)	Top of Sep. (6/30)
Date/Time Sampled	6/20/97 13:15	6/30/97 13:15	6/30/97 13:15	6/30/97 14:20	6/30/97 17:45	6/30/97 17:15	6/30/97
9,10-Anthracenedione	ND	ND	ND	NA	NA	ND	163
7,8-Benzoquinoline	ND	ND	ND	NA	NA	ND	170
Carbazole	ND	ND	ND	NA	NA	166	451
Naphthalene	ND	46	11	NA	NA	4188	13503
2-Methylnaphthalene	ND	ND	4	NA	NA	19119	50787
Acenaphthylene	ND	34	36	NA	NA	45	166
Acenaphthene	3332	ND	18	NA	NA	1955	7717
Dibenzofuran	3358	ND	26	NA	NA	1758	6658
Fluorene	2544	34	27	NA	NA	1241	4843
Phenanthrene	19281	9281	5446	NA	NA	5077	17438
Anthracene	2925	3189	1517	NA	NA	1039	4525
Fluoranthene	1730	8868	4700	NA	NA	1640	6483
Pyrene	1628	7158	3658	NA	NA	1153	4672
Chrysene	ND	115	32	NA	NA	ND	64
Benzo[b]fluoranthene	ND	ND	ND	NA	NA	ND	ND
Benzo[k]fluoranthene	ND	ND	ND	NA	NA	ND	ND
Benzo[a]pyrene	ND	ND	ND	NA	NA	ND	1
Indeno[1,2,3-cd]pyrene	ND	ND	ND	NA	NA	ND	ND
Dibenz[ah]anthracene	ND	ND	ND	NA	NA	ND	ND
Benzo[ghi]perylene	ND	ND	ND	NA	NA	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	NA	NA	12	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	NA	NA	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	NA	NA	20	ND
Pentachlorophenol	ND	ND	ND	NA	NA	612	ND
Total Oxygenates (µg/L)	0	69	125	—	—	201	830
Total PAH (µg/L)	34797	28725	15475	—	—	37381	117479
Total Cl-Phenols (µg/L)	0	0	0	—	—	644	0
Total GC-MS (µg/L)	34797	28794	15601	—	—	38226	118309
% Oxygenates	0.0	0.2	0.8	—	—	0.5	0.7

Table 9. Results of chemical analyses (semivolatile organics, µg/g) for miscellaneous free product samples

Sample Name	BYS (Filtered)	Gravity Separator	DAFT	Grav. Sep. (Sludge)	S-13- Crystals	S-13- Crystals	DAFT	DAFT	S-12 Scale	S-13 Scale (High)	S-13 Scale (Low)	S-15 Scale	EW-2 Scale	Tank #2 (Top)	Tank #2 (Bottom – Emulsion)
Date Sampled		6/19/97	6/19/97	6/19/97	6/30/97	6/30/97	7/16/97	7/15–7/16	10/17/97	10/17/97	10/17/97	10/17/97	10/17/97	10/26/97	10/26/97
Phenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3- and 4-Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic acid	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorenone	804	586	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthrone	115	ND	ND	ND	125	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9,10-Anthracenedione	105	ND	ND	ND	629	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7,8-Benzoquinoline	891	374	ND	ND	214	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	2271	727	ND	ND	244	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	23026	32768	667	3	4	79	22818	23051	ND	ND	82	3	ND	41500	17177
2-Methylnaphthalene	32501	56434	1879	5	ND	ND	95566	95859	ND	ND	267	21	ND	94280	63398
Acenaphthylene	244	273	ND	3	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	149
Acenaphthene	24240	30303	3980	22	ND	ND	8556	8626	ND	ND	961	262	ND	10600	6391
Dibenzofuran	15010	18586	2788	12	123	ND	7030	7010	ND	ND	728	228	ND	7520	5021
Fluorene	17814	21848	3717	28	633	556	4848	4798	ND	ND	908	360	ND	5610	3574
Phenanthrene	29097	56838	17505	234	32149	87143	12899	13232	10	3	8700	4616	3	14020	10490
Anthracene	6875	12333	2576	93	44167	292857	3343	3455	4	2	3907	987	1	3750	2973
Fluoranthene	20840	30737	10040	355	27149	40675	2475	2525	64	5	10603	5714	4	2080	1623
Pyrene	21804	25061	8576	341	22038	32222	2091	2091	90	5	8880	4888	4	1530	1132
Chrysene	6200	6253	1909	142	476	437	ND	ND	336	9	871	578	2	ND	94
Benzo[b]fluoranthene	1638	2192	1313	58	ND	ND	ND	ND	25	3	70	92	ND	ND	ND
Benzo[k]fluoranthene	1461	2030	1222	51	ND	ND	ND	ND	30	5	107	127	ND	ND	ND
Benzo[a]pyrene	1675	2051	ND	63	ND	ND	ND	ND	7	2	73	79	ND	ND	ND
Indeno[1,2,3-cd]pyrene	469	ND	ND	19	ND	ND	ND	ND	1	ND	ND	ND	ND	ND	ND
Dibenz[ah]anthracene	263	ND	ND	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[ghi]perylene	313	ND	ND	15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	267	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Oxygenates (µg/g)	1024	586	0	0	754	0	0	0	0	0	0	0	0	0	0
Total PAH (µg/g)	206632	298808	56172	1449	127202	453968	159626	160646	568	34	36156	17953	13	180890	112022
Total Cl-Phenols (µg/g)	267	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total GC-MS	207923	299394	56172	1449	127956	453968	159626	160646	568	34	36156	17953	13	180890	112022
% Oxygenates	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0